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VARIABLE STAR WORK FOR THE AMATEUR WITH A SMALL TELESCOPE.

WILLIAM TYLER OLCOTT.

In all the literature of POPULAR ASTRONOMY and particularly in the books written for the benefit of those possessed of only a modest telescopic equipment, we find, strange to say, little if anything on the subject of variable stars. Even in Webb's "Celestial Objects," probably the most comprehensive of all works for the amateur astronomer, there is merely a reference to a few of these interesting stars, and their location given in terms of right ascension and declination.

There is no guide, to the writers knowledge, as to how these stars may be identified, or in what manner they may be intelligently observed.

While an equatorial mounting is really of great assistance in locating variable stars, as they are for the most part only telescopic objects, still it is possible to identify and observe many of them with only a simple tripod mount, such as the writer supposes the great majority of the owners of small telescopes are supplied with. Once the variable is located, the field affords a mental picture which is easily found again, so that it is possible in a short time to observe the variable with great facility.

A good star atlas is a desideratum. There are a number of good ones on the market, such as Upton's, Schurig's, and Klein's. The writer finds the latter most satisfactory. This locates many of the variables, and the student will find it to his advantage to plot those he intends to observe that do not appear on the chart. The bright stars in the vicinity of the variable should be noted, in order that the location of the field may be more readily determined.

There are some twenty-five variable stars, with which the writer is familiar, that can easily be found by simply sweeping for the fields, after their location is approximately determined. Six of these are even easier to find, for they include naked eye stars in the fields, or near by, which enable the observer to locate the variable star easily.

In order, therefore, to outline the method of observation, these stars have been selected, as the amateur should have no difficulty in identifying them, and once found and observed for a time, the fascination of the work is sure to stimulate him to further efforts.

Every owner of a small telescope, who uses it to any extent, must have felt at some time or other that, aside from the personal gratification of seeing the wonders that the glass reveals, and affording his friends a like opportunity, there was little to be accomplished with such an equipment, that would be worth while; and it is a fact that only by the observation of variable stars can the amateur turn his modest equipment to practical use, and further to any great extent the pursuit of knowledge in its application to the noblest of the sciences.

It is only right that a valuable instrument should be used, yet many telescopes owe their disuse to the fact that their owners are unaware that even a small glass may render science a valuable service.

With a desire to direct attention to a line of work that is within the reach of every owner of a telescope of 3-inch aperture or larger, this article is written. The writer has had but a brief experience with the work, but it has yielded so much pleasure and satisfaction, and furnishes such excellent material for the amateur astronomer's observation, that he feels sure that, once the method of procedure is made clear and the fields here given are identified, many will take up the work, who have not as yet dwelt on its possibilities, solely because the books fail to afford definite information relative to the subject.

The writer mentions only long period variables, as they are the easiest to observe, and do not make as great demands on the observer's time as is the case with the observation of variable stars of short period.

There are certain observatories that make a specialty of the observation of variable stars, notably the Harvard College Observatory at Cambridge, Mass., to the Director of which,

Professor E. C. Pickering, the writer is much indebted for assistance and encouragement, and from whom he received the charts reproduced in this article. The institution welcomes all intelligent observations of variable stars and encourages their observation.

It is best to use a low power in the study of variables. The writer uses a power of 30 diameters with a 3″ and 5¼″ refractor, which is satisfactory, and reveals with the latter glass stars of the 12th magnitude.

The six variables selected for discussion as being easy of observation and suitable for observers with tripod mounts are:– 193449 R Cygni, 072708 S Canis Minoris, 180531 T Herculis, 162119 U Herculis, *170215* R Ophiuchi, and 103769 R Ursae Majoris.

The variable stars are designated by a letter taken from the latter part of the alphabet, preceded by a number, the first four figures of which indicate the stars right ascension in hours and minutes, and the two last figures, its declination in degrees. If the star is south of the equator the number is underlined in manuscript, and italicized in print.

In the case of the stars metioned the range is given, that is, the difference in the star's magnitude at maxima and minima, also the period, which is the elapsed time in which the change is effected.

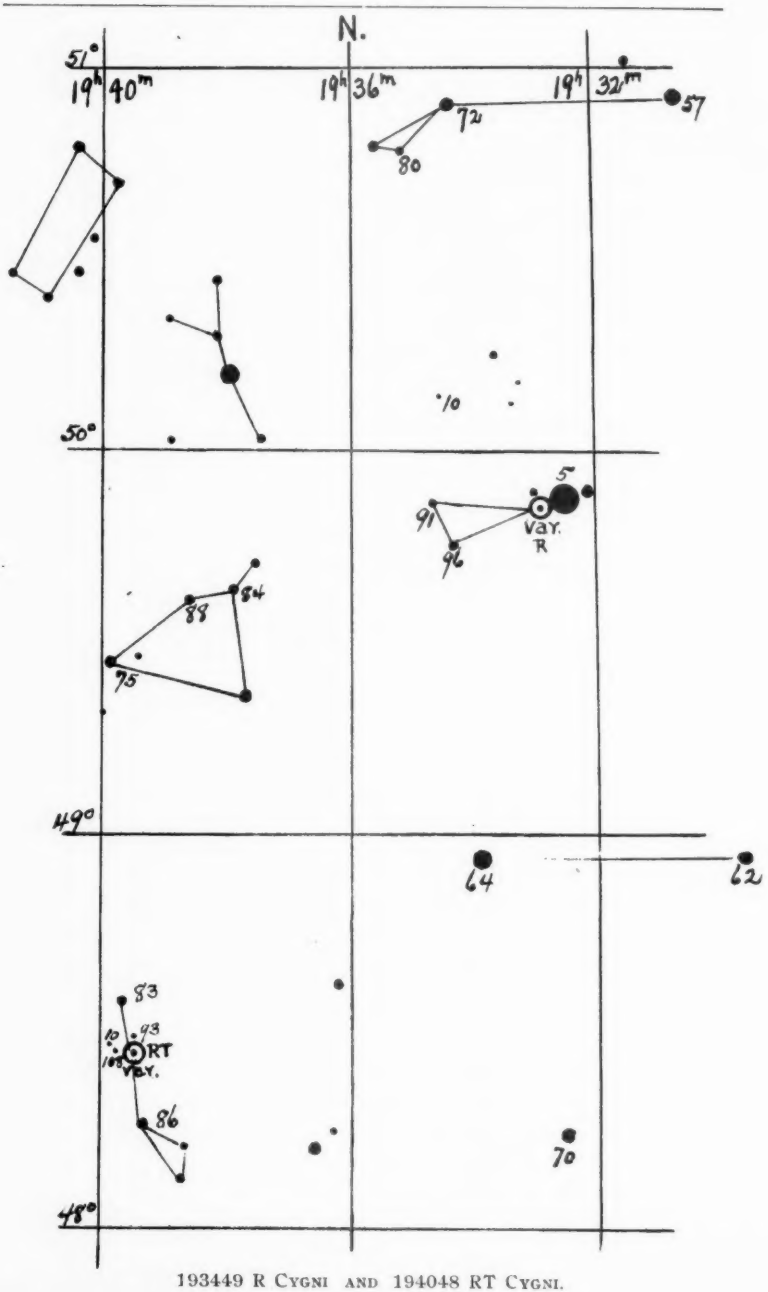
193449 R Cygni

The variability of this star was discovered by Pogson in 1852. Its range, according to the latest Harvard publications, is from the 6.6th to the 13.9th magnitude, and its period 426 days.

The fourth magnitude stars ι and κ Cygni point to a fifth magnitude star which lies but a few degrees from ι in the direction of δ Cygni, as the star atlas indicates. Set on this 5th magnitude star which appears on the following chart, and the variable R Cygni, marked "VAR", is located.

Great care should be taken in identifying the variable. If it is not visible at the date of the observation, the faintest star of known magnitude in the field should be noted, in this case <10.9, indicating that the variable is fainter than this star.

On all the charts the magnitudes of certain stars are indicated to the nearest tenth, the decimal sign being omitted to avoid confusion. The method of observation, if the variable is visible, is to find two stars, one fainter and one brighter than the variable appears to be, and then to determine by



193449 R Cygni and 194048 RT Cygni.

comparison what the difference in light value is. The estimated magnitude of the variable is a sort of proportion of magnitude between the known magnitudes of the brighter and fainter comparison stars used. It is all a question of training the eye, and it is astonishing how quickly a moderate degree of accuracy is acquired.

A careful record should be kept of each observation as follows (taken from the writer's note book):—

Date	Nov. 15, 1910.
Star	193449 R Cygni.
Estimate	9.1
E. S. T.	7:25.

This is also the record sent to the headquarters each month.

The Director of the Harvard College Observatory will furnish, on application, blanks on which to record observations that are to be submitted to him.

If an equatorial mount is used, the personal record includes, in addition to the above, the sidereal time, the hour angle, and the declination. The reason for noting this data is that it affords evidence in case any question arises as to the identification of the variable.

The charts here given indicate the appearance of the variable fields if visible to the naked eye. The celestial eyepiece, of course, reverses this, and for convenience in observing the charts should be inverted. When the field is rising in the east, the north point should be at the right hand, when setting, at the left. This is a point which may cause a little confusion at the start, but bearing the rule in mind the observer should have little trouble.

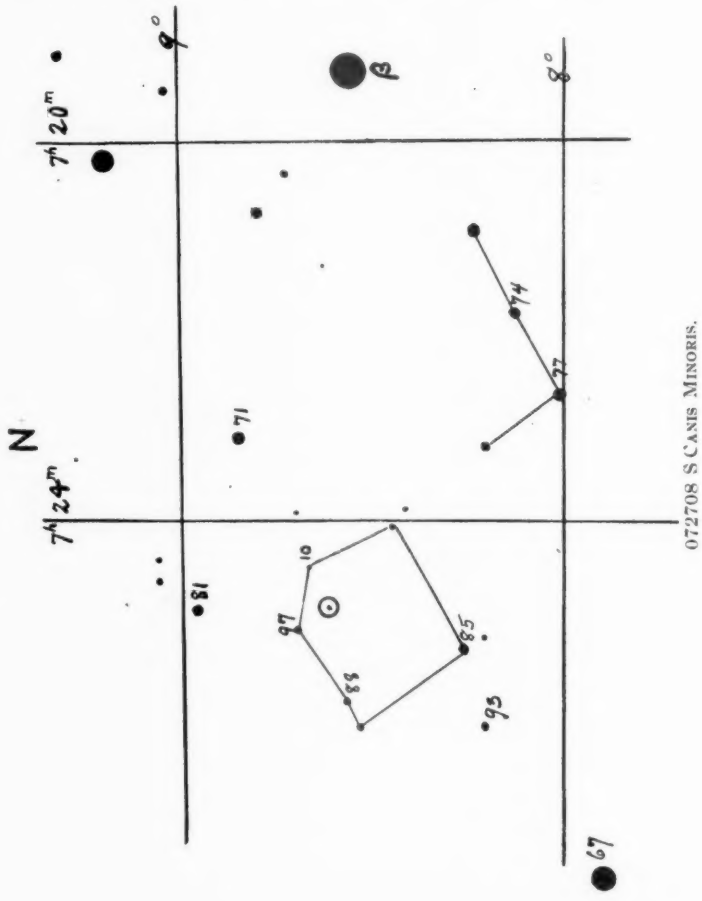
By connecting certain star groups with lines, as is indicated, geometric figures are formed which greatly facilitate identification of the fields, and the observer will soon learn to connect these groups as his fancy dictates. It is well also to apply the diameter of the telescopic field to the chart, as by so doing the observer knows what stars are in the field with the variable.

Only the prominent star groups, the figures that are likely to fix the attention in sweeping, are indicated on these charts. They should be sufficient in these cases where only a tripod mount is used and the variable is close to the naked eye star. The important stars to locate are the variable and the comparison stars. The magnitudes of these latter have been carefully determined at the Harvard College Observatory by

photometric methods. They are also on the visual basis and all reduced to a uniform photometric scale.

072708 S Canis Minoris.

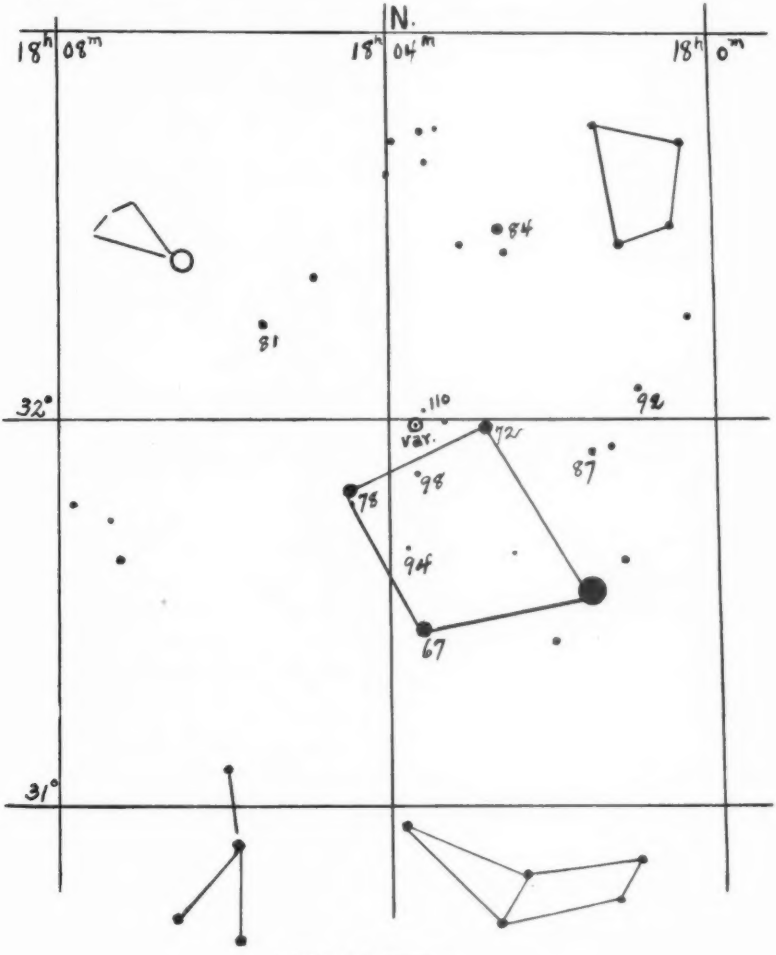
This star is rising in the early evenings of the first of the year as R Cygni sets. It is easily found, being almost in the field with β Canis Minoris, which appears on the chart. Close to β is the bright right angle of stars which point out a faint pentagon and serve to locate the variable. The variability of this star was discovered by Hind in 1856. Its range is from the 7th to the 11th magnitude, its period 330 days.



072708 S CANIS MINORIS.

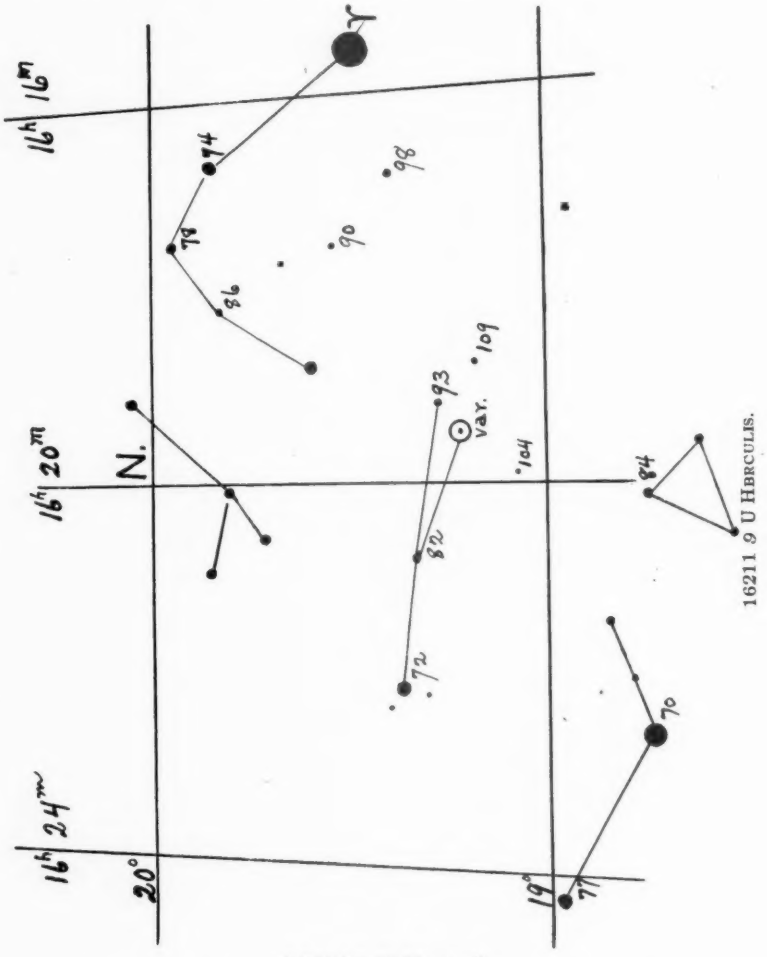
180531 T Herculis.

This variable star is extremely easy to locate, as a glance at a star atlas will reveal. It lies between two fifth magnitude stars in the hand of Hercules, which is depicted on the old maps as grasping Cerberus. Both of these stars appear as the largest circles on the chart. There are several characteristic figures in this field as indicated which greatly facilitate its identification.



180531 T Herculis.

This variable was discovered at Bonn in 1857. Its range is 7.2 to 13.6, and its period 165 days. The star is deep red in color, as are many of the variable stars, but the color changes during the course of the light variations.



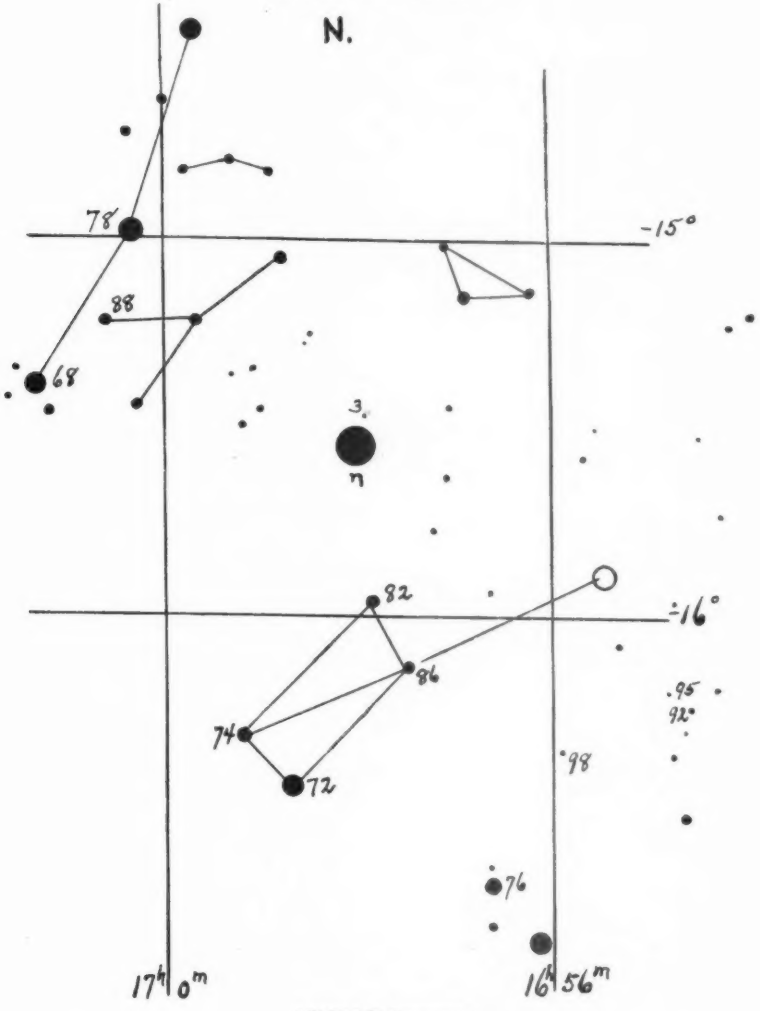
16211 *g* U Herculis.

162119 U Herculis

This star will be found close to the third magnitude star, γ Herculis, which is represented by the largest circle on the chart. The line under it indicates that the star is a double.

This star's variability was discovered by Hinke in 1860. Its range is from 6.4 to 12, and its period 409 days.

170215 R Ophiuchi

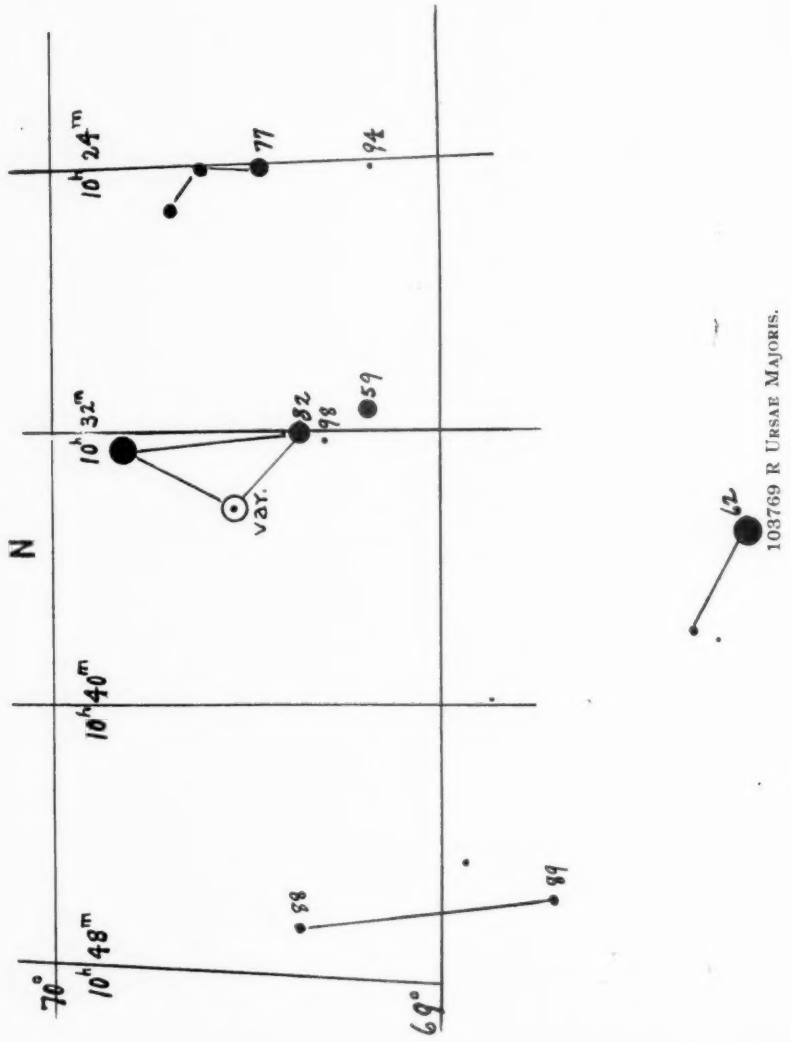


170215 R Ophiuchi.

The variability of this star was discovered by Pogson in 1853. Its range is from 7.1 to 13.6, and its period 303 days. It is almost in the field with the third magnitude star,

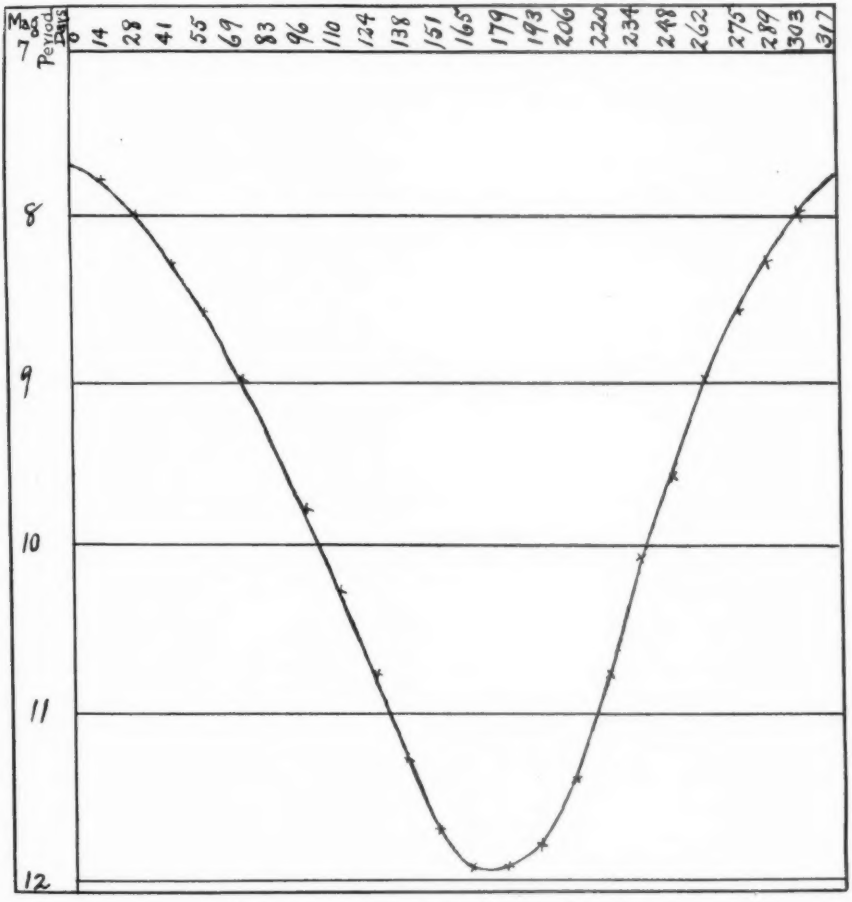
η Ophiuchi, and hence is easily located. Note that the designation number is italicized, indicating that the star is south of the equator. The parallelogram of stars just south of η, which is outlined, serves to locate the variable.

103769 R Ursae Majoris.



Pogson discovered this star to be a variable in 1853. Its range is 7.0 to 13.5. Its period is 302 days.

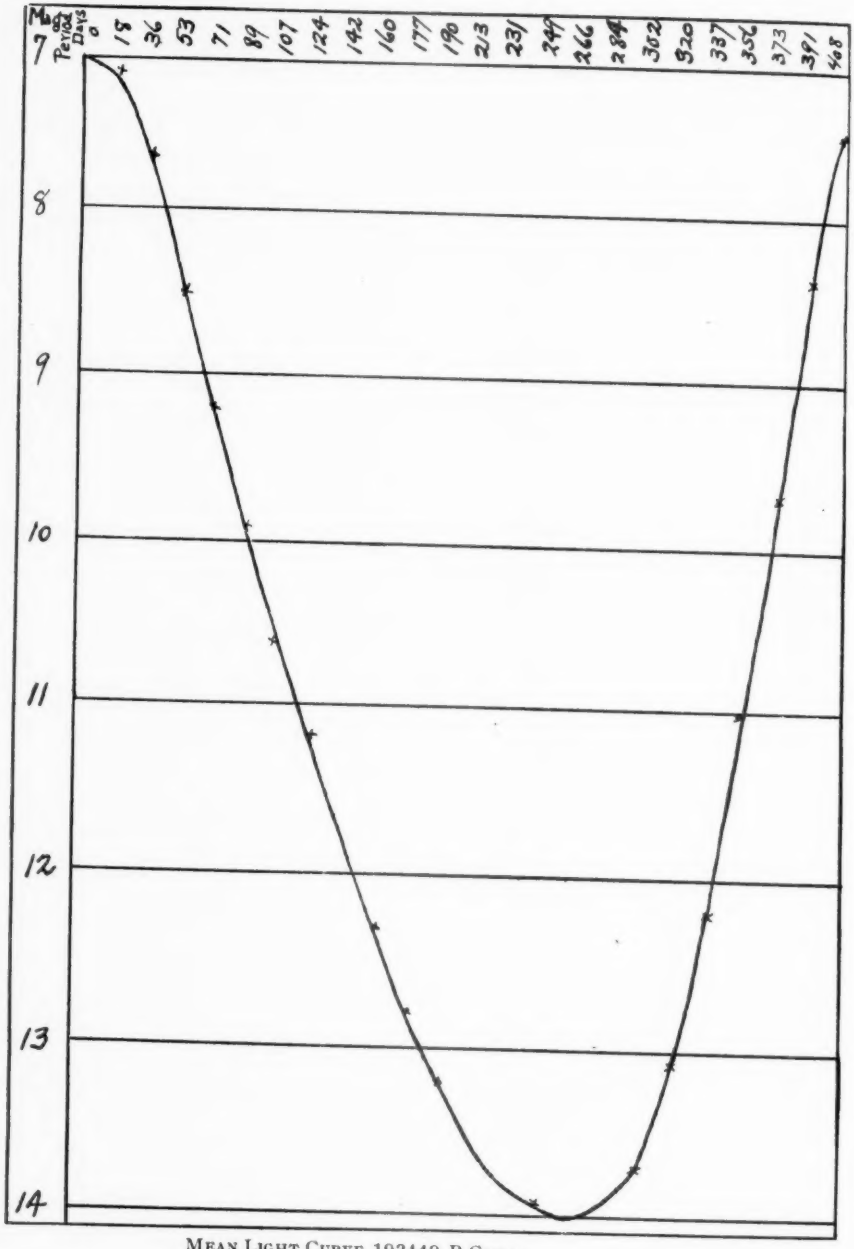
About 8° north of α Ursae Majoris note a fifth magnitude star with one of the sixth magnitude just south of it. κ and



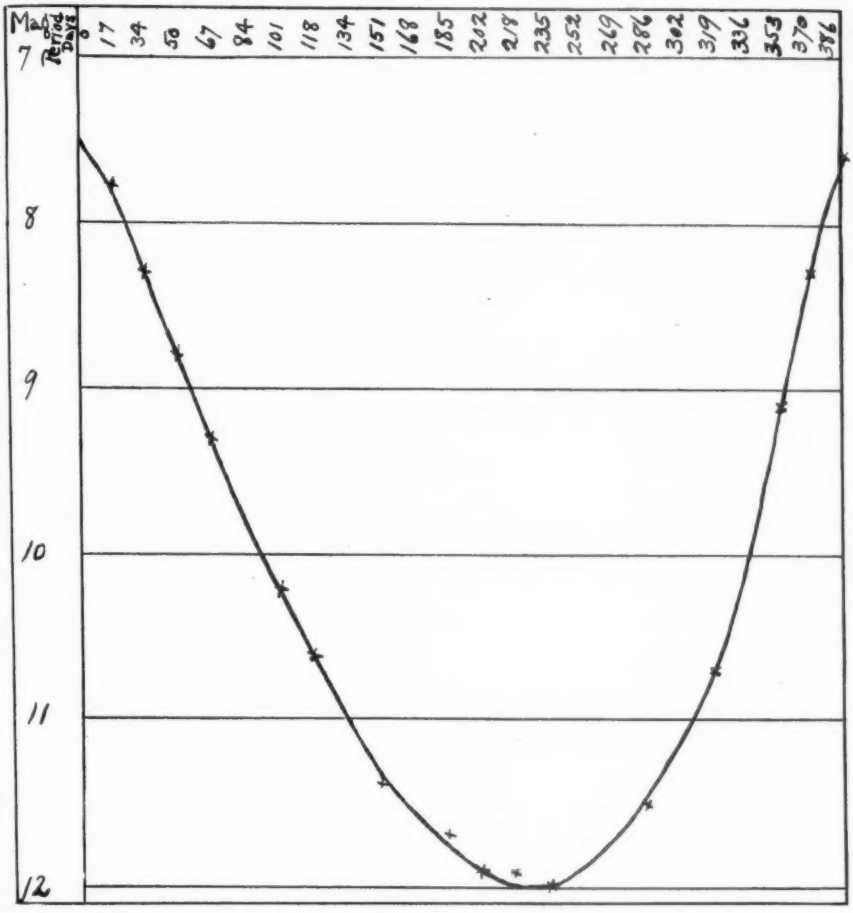
MEAN LIGHT CURVE 072708 S CAN. MINORIS.
UNIFORM VARIATION.

λ Draconis point to the pair. Set on these stars and the variable should be in the field or close to it.

After a series of observations the light curves of these stars may be traced on coördinate paper and compared with the



MEAN LIGHT CURVE 193449 R CYGNI.
RAPID INCREASE



MEAN LIGHT CURVE 162119 HERCULIS
BROAD MINIMA

mean curves here given.* The comparison of the light curves of the various types of variable stars is an exceedingly interesting study.

* These curves were plotted from data contained in Vol. 57 Part I of the *Annals* of the Astronomical Observatory of Harvard College, and illustrate three types of curves. The curves of T Herculis and R Ophiuchi are similar to the curves of S Can. Minoris, while the curve of R Urs. Maj. resembles that of R Cygni.

As the curves given are the mean curves, seeming differences derived from observations are not necessarily erroneous.

If the stars here mentioned are found and observed for a time, the fascination of the study will weave its spell, and the observer will be anxious to explore the heavens for new fields. He will not be content until he has seen with his own eyes Mira, o Ceti, the most celebrated of all long period variables, and watched its wondrous changes.

In addition to the stars here mentioned there are many variables that can be easily found with a little sweeping, if their general location is well determined, and there is a delight in the sight of the new field that is akin to the discovery of a rare treasure.

The only requisite for the work, aside from a glass of three-inch aperture or larger, and good eyesight, is a reasonable amount of perseverance and patience, but the pleasure of the find after a laborious search is ample compensation.

It may appear at first blush that the changes in magnitude in these stars is so slow that the work would be monotonous. This might be the case if the observer were sure of fine weather and no interruptions, but a good night is an exception when we consider that the Moon is apt to interfere somewhat with the work, and the demands on the average man's time prevent anything like continuous observation. It has been the writer's experience that changes are generally to be noted in almost every observation.

In conclusion the observation of variable stars is heartily commended to all amateur astronomers as a means of putting the telescope to a practical use, and as a source of unlimited pleasure and intellectual profit. The study of these stars stimulates observation, a delight in itself and well worth while. It also calls for the keeping of a careful record of what is observed, a habit which all amateurs should cultivate.

It is only by the collection of an enormous amount of data relative to these mysterious stars that the laws which govern their changes in magnitude can be revealed, and this end can best be accomplished by the coöperation of observers in all parts of the country, so that the weather will in no wise interfere with a continuous set of observations. The writer will gladly answer questions relative to the work, and direct attention to other stars on his list that should prove easy to find even if a tripod mount is the only one available.

Norwich, Conn. Jan 1911.

INTERESTING COMETARY STATISTICS.

H. C. WILSON.

In the October number of the *Bulletin Astronomique* Mr. A. Borrelly, astronomer at the observatory of Marseilles, gives some rather unusual and interesting statistics concerning the comets which have appeared since the beginning of the sixteenth century. The following notes are in most cases free translations of abstracts from Mr. Borrelly's paper.

Of the 376 comets which have been discovered since the invention of the telescope, more than one third were discovered in France, Marseilles leading the list with 64 and Paris following with 46 comets to her credit. Lick Observatory comes fifth on the list, with 14 comets.

The following table gives the entire list of observatories credited with comet discoveries.

	Comets		Comets		Comets
Marseilles	64	Echo Mountain	3	Coburg	1
Paris	46	Haarlem	3	Dillingen	1
Geneva	16	Kiel	3	Doumazan	1
Florence	15	Limoges	3	Dorpat	1
Lick	14	Nauen	3	Pekin	1
Nice	12	Princeton	2	Venice	1
Berlin	12	Thaines	2	Elsternwich	1
Nashville	10	Albany	2	Genéve	1
Rochester	10	Danzich	2	Greenwich	1
Rome	9	Lauasnne	2	Pola	1
Goettingen	8	Cape	2	Yale	1
Phelps	8	Palermo	2	Hamburg	1
Leipzig	7	Paramata	2	Houslaw-Heat	1
Slough	7	Parme	2	Johannesburg	1
Uraniburg	7	Semflemburg	2	Rio-Janeiro	1
Cambridge	7	Viviers	2	Yerkes	1
Bologna	5	Windsor	2	Langord	1
Heidelberg	5	Aix	1	Lisbon	1
Karlsruhe	5	Ann-Arbor	1	Marathon	1
Marlia	5	Athens	1	Madras	1
Milan	5	Bergerac	1	Sidney	1
Strassburg	5	Bombay	1	New York	1
Altona	4	Branscombe	1	Naples	1
Bristol	4	Breslau	1	Nimes	1
Moscow	4	Cassel	1	Olinda	1
Bremen	3	Chemnitz	1	Taunton	1
Copenhagen	3	Choisy-le-Roi	1	York	1

More comets have been discovered in the second half of the year than in the first half, July being the banner month and May having the smallest number.

First semester	Comets		Second semester	Comets	
January	26		July	44	
February	23		August	34	
March	32	168	September	34	208
April	40		October	28	
May	20		November	34	
June	27		December	34	

Nearly two thirds have been discovered in the eastern sky and only a little over one third in the west. One would think *a priori* that the greater number of comets would be found west of the meridian, as that is undoubtedly the region of the sky most frequently explored.

The mean hour of cometary discovery is $12^h\ 50^m$, with a maximum between 13^h and 18^h.

More comets are discovered in the morning than in the evening, and when the Earth is proceeding from the summer to the winter solstice. This agrees with Schiaparelli's discovery that the shooting stars which are connected with comets are more numerous in the morning and in the second half of the year.

Of the 376 comets, 106 were periodic, 19 having been observed at more than one return. Three comets are regarded as lost, 65 have been visible to the naked eye and 7 were seen in the daytime near to the Sun.

The most remarkable fact to which Mr. Borrelly calls attention is that, as a rule, the appearance of a brilliant comet during the last half century has been followed by the discovery of one or more periodic comets. Thus the great comet of 1843 was followed by the discovery of Faye's periodic comet Nov. 22, 1843, that of 1850, by d'Arrest's on June 27, 1851, that of 1861, by 1862 (III). In 1881, 1882, 1883 there were three brilliant comets. They were followed by the periodic comets, Denning 1881 (V), Swift 1881 (VIII), Barnard 1884 (II), Wolf 1884 (III), Brooks 1886 (IV), Finlay 1886 (VII). The comets, 1887 (I), 1888 (I), and 1889 (IV), were followed by the numerous discoveries of periodic comets Brooks 1887 (II), Barnard 1889 (III), Brooks 1889 (V), Swift 1889 (VI), Denning 1890 (VI) and Holmes 1892 (III).

The splendid Rordame-Quenisset comet in 1893 was followed by the periodic comets Denning 1894 (I), Swift 1895 (II) Perrine 1895 (IV), Giacobini 1896 (V), Perrine 1896 (VII) and 1898 (I). There were no more great comets until 1903 and no more periodic comets showed themselves until the one discovered by Borrelly in 1904; then came Kopff's 1906 IV and Metcalf's 1906 VI. The next splendid comets were Daniel's

in 1907 and Morehouse's in 1908; soon after comes Daniel's periodic comet 1909 *e*.

The great comets of 1858 and 1874 were not followed immediately by the discovery of any periodic comets. The above are rather striking coincidences but they are probably only accidental coincidences, except as they resulted from the stimulus to search for new comets which is given by the appearance of every brilliant one. Mr. Borrelly however thinks that another conclusion is to be drawn and that is that the periodic comets are offshoots from the great ones, captured by the attraction of the planets and that the great comets may be called the generators of the little ones. Quoting Bredichin's views he says: "A parabolic comet may, in the vicinity of its perihelion passage, have several successive emissions from its nucleus. Part of these will describe hyperbolas, part of them ellipses. The portions detached may be large enough to form veritable new comets, among others those having elliptic orbits."

According to the views of Bredichin it follows that periodic comets are, like the swarms of meteors, the product of the disintegration of great comets and have their birth near the Sun.

M. Radau, in a remarkable study of comets and shooting stars published in the *Annuaire du Bureau des Longitudes*, discussing facts observed by Barnard says, "those examples and others which we could cite prove that the disintegration of comets is not a pure hypothesis, since it takes place sometimes under our very eyes. The disappearance of Biela's comet, replaced by a shower of Bielids, furnishes a substantial proof of the theory that shooting stars are the debris of comets."

M. Schulhof in his studies on this subject published in the *Bulletin Astronomique*, while recognizing that the views of Schiaparelli have found very favorable reception and are generally adopted today, states that, "there are a certain number of facts which it is impossible to explain on this theory and which compel us to admit that at least certain comets have their birth in the solar system itself." It may be that the capture of a comet does not go back to the remote past. One may even make this supposition in regard to the periodic comets. While some of them are disintegrating more or less rapidly, others are forming among the innumerable corpuscles which circulate in elliptic orbits around the Sun. This reconstitution is due to electric and magnetic forces which have their seat in the corpuscles themselves. If comets possess, as is quite probable, an indestructible nucleus, this will serve as

the center of attraction around which the corpuscles will gather together. This hypothesis is very seductive and has been more or less vaguely formulated by different astronomers and quite recently by M. Herz. It is only to the first matter of the comet, which it had when incorporated into the solar system by capture from an almost parabolic orbit, to which we can attribute a long existence. Each of these comets is sooner or later disintegrated, the debris becoming more and more scattered along elliptic orbits differing but little; from time to time these corpuscles form new temporary agglomerations, which are our periodic comets, destined to dissolve themselves in their turn. This mode of formation is even indicated by the granular aspect of these comets, which is, according to Barnard, an almost sure index by which he could predict, even before the calculation of the orbit, that a comet would be periodic.

"If the suggested mode of formation of periodic comets conforms to the reality, one can understand better how it is that there are so many comets which have a common point of proximity and for which the constant of Tisserand is identical."

These statistics show that one should search for comets in all parts of the sky but preferably toward the sunrise, since the chances there are greatest. It is necessary to be patient in these explorative searches and we must not forget today that, in spite of the powerful means at hand, the astronomer who can observe six or eight hours on the same night will have the advantage over the one who observes only two or three hours. For the search for periodic comets after the apparition of a splendid comet, presenting the requisite physical characteristics, it is only necessary to trace the trajectory of the comet, which is supposed to be the generatrix, upon a celestial globe and explore the sky on either side of it in all directions and as far as possible.

CELESTIAL PHOTOGRAPHY.

ARTHUR K. BARTLETT.

The new science of celestial photography, which ranks in importance next to spectrum analysis, has become almost indispensable to the astronomer in his observations of the heavens, and it has recently been developed to such an extent that it promises to rival, if it does not altogether supersede the telescope, as a means of astronomical research. Already it has succeeded in supplementing human vision almost beyond belief, and has revealed the existence of celestial objects so faint and obscure that the most powerful telescopes have failed to detect them. Could the famous astronomers, Copernicus, Galileo, Kepler and Newton, return to our Earth from the realms of the unknown, and be permitted to revisit the scenes of their former greatness, it is difficult to imagine which would most excite their interest and astonishment—the wonderful revelations of the telescope, the brilliant researches in spectrum analysis, or the glorious achievements of celestial photography, the marvelous science that has recently developed the most surprising results, and expanded our views of the august scenes of creation to an almost unlimited extent, having thus laid a foundation for our acquiring an approximate idea of the infinity of space, and for obtaining still farther glimpses of celestial scenery than even the largest telescopes have revealed to our observation. As a recent writer has well remarked, "The many wonderful discoveries in astronomy recently made by the aid of photography have seemed to leave the older methods of astronomical investigation far in the rear."

Many intelligent persons, who for the first time were shown a stereoscopic picture of the full Moon, have doubtless mistaken it for a view of a peeled orange, and the truth is, that an ordinary photograph of the full Moon does bear a striking resemblance to a peeled orange. The great crater, Tycho, looks very much like the "nib" from which the stem has been removed, and the long lines of trap rock or whatever they may be, that radiate from the crater, resemble the whitish streaks marking the divisions of the orange. But in larger and better photographs, and especially in those taken at one of the quarters, instead of at full Moon, all the resemblance

to a peeled orange at once disappears; and where the line of daylight falls, along the Moon's "terminator," the saucer-shaped craters, with their sharp central mountain peaks, and the long jagged shadows cast by lofty ranges, are revealed with surprising distinctness in the picture.

Photographs of the Moon are not the mere scientific curiosities that many persons suppose them to be, for they not only serve a useful purpose in astronomical research, but they also have a commercial value. Few collections of stereoscopic views are destitute of one or more of these photographs, and they are now as popular as the pictures of some actresses or other persons well known to to the public. The method by which these views of the Moon are obtained will doubtless be interesting in connection with this sketch. Nearly everybody knows that a stereoscopic picture of a person or a waterfall is obtained by combining two pictures of the object taken from different standpoints, so that each shows a little around the side, and the two being combined make the object appear to stand out in lifelike perspective. To produce the same effect with Moon, advantage is taken of the fact that it vibrates, or rolls a little upon its center, in revolving around the Earth, so that at one time we see a little more of one side than usual, and at another time more of the other side. This motion is known as the Moon's libration. When two photographs of the Moon, taken at opposite librations, are combined by the stereoscope, the lunar orb appears suspended before the eyes like a ball that the hand can grasp.

Every person of mature age must have frequently seen what is known as "the old Moon in the new Moon's arms." When the Moon, only a few days after passing the Sun, appears as a narrow crescent in the western heavens, the unilluminated portion of its disk is seen shining with a faint, ashy light. This light comes from the Earth and is reflected back by the Moon, just as the landscape is faintly visible in full moonshine. A few years ago, M. Janssen, of Paris, succeeded in producing photographs of the Moon that exhibited this phenomenon very distinctly. The photographs of the Moon are obtained by the aid of telescopes, the prepared plate being fixed at the focus of the instrument in the place of the eye-piece. They are produced only one or two inches in diameter, and of course have to be enlarged. Good pictures will permit of being enlarged to a diameter of two or three feet. The late Professor Rutherford, of New York City, who was an expert in this interesting

department of astronomy, used a refracting telescope to photograph the Moon, the object glass being peculiarly corrected so as to focus the chemical or actinic rays. But many other astronomical photographers use reflecting telescopes, in which a concave mirror takes the place of an object-glass.

The Moon is not the only celestial object whose picture can be taken. Photographs are also made of the Sun, exhibiting the dark spots and the interesting phenomena observed during a total eclipse. The planets Venus and Mercury have been photographed while in transit across the Sun's disk. Even the stars can be photographed, and a few years ago Professor Draper succeeded in photographing the great nebula of Orion, which most astronomers believe to be an enormous mass of gaseous matter, containing in itself the germs of future worlds and suns. More nebulae are at present known to astronomers than there are stars visible to the naked eye in the entire firmament, and they appear like faint spots of light. These objects are situated at immeasurable distances from our Earth, and all except the great nebula in Andromeda are invisible to the naked eye. On a clear night, during the absence of the Moon, this remarkable nebula appears to persons having keen vision as a faint, cloudy spot, of an oval form, and has frequently been mistaken for a comet. From time immemorial this wonderful object has been an enigma to astronomers, and its true nature was never understood until quite recently, when the late Professor Isaac Roberts obtained an excellent photograph of the nebula after exposing the plate for four hours; and it was then found to be composed of numerous rings of gaseous matter apparently in an intensely heated condition, and doubtless passing through some marvelous process of evolution.

Many other wonderful and important applications of photography to the heavens have been made during the past few years, and by its aid a new nebula was discovered in the Pleiades by the two Henry brothers, of the Paris observatory, in November 1885. The most wonderful circumstance in connection with this discovery is, that though the nebula is plainly impressed on the photographic picture of this famous star-cluster, it has been, thus far, too faint to be visible to the human eye even in the most powerful telescopes. In the Pleiades, which form one of the most interesting clusters of stars known in the firmament, the casual observer may easily perceive six stars belonging to the group, and persons with

acute powers of vision may see twelve stars, but a large telescope will reveal at least 200 stars that are invisible to the naked eye. Among the visible stars that form this cluster, there is one of the fifth magnitude, known to astronomers as Maia, and the new nebula is apparently associated with this star, from which it seems to escape, first directing its course towards the west, then turning suddenly to the north, and gradually fading into invisibility. The new nebula is very intense, is of a plainly marked spiral form, and its extent, as indicated in the photograph, is about three minutes of arc in the heavens. Thus the sensitized plate of the camera, when applied at the focus of a properly constructed telescope, has proven more effective than the human retina, and has so to speak, enabled us to see beyond the reach of human vision by means of the pictures it makes of objects which escape the eye.

If the operation of making "the inconstant Moon" sit for her likeness seems wonderful and almost incredible, still more marvelous, and also more difficult, is the process of taking pictures of the stars, for the Moon is so near and bright that it is comparatively easy to obtain a photograph of her disk, but most of the stars are so faint and far away that only after a long exposure will they succeed in impressing their image on the sensitive plate used for this purpose. During the time occupied in this very delicate operation, special care must be taken to exclude all light except that coming directly from the stars, for this would act on the prepared plate and obliterate the image; and it is also necessary that the telescope should be moved smoothly and guided by the most perfect clock-work so as to follow a star, and keep it always at the same point of the plate during the long interval that the exposure must be continued. Professor Ball, the eminent astronomer royal of Ireland, in a recent article on "Photographing the Heavens,', says: "Even though the plates are the most sensitive that can be manufactured, it is often advantageous to expose for a period, not of seconds or minutes, but actually of hours. On some of the wonderful pictures which Mr. Isaac Roberts has obtained, stars will be seen that have taken not less than four hours to engrave their little marks on the plate. Indeed, with every increased minute of exposure more and more stars, apparently without end, succeed in leaving their impressions. Many of these stars are too faint to be ever seen in the greatest of telescopes."

It is gratifying to know that America is far ahead of Europe

in this new and marvelous science of celestial photography. Professor S. W. Burnham, the famous double star observer of Chicago, has for several years past been perfecting himself in the art of photography with the purpose of applying it to astronomical observations, and in this work he has been very successful. Mr. Burnham is considered excellent authority in this department of research, and in a valuable paper on "The Camera for Celestial Photography," he says: "There is this difference between terrestrial and celestial pictures: in the former we rarely get as much as we can see readily with the naked eye from the point where the picture is taken, while in the latter we can easily get infinitely more by prolonging the exposure. If the following is perfect, and the camera is accurately focused, the smaller stars will be exceedingly minute specks, and if the exposure is an hour and upwards, there will be thousands of these tiny points scattered over the plate where perhaps only a score or two of stars are visible to the naked eye, while not a dozen of them could be seen at all on the ground glass of the cemera. Lantern slides from such negatives are more wonderful and interesting than any other stellar photographs, and when thrown upon the screen, it is difficult for many to believe that such a wilderness of stars could be readily photographed with a lens, through which not one in a thousand could be seen on the ground glass." Professor Barnard, of the Yerkes Observatory, has distinguished himself as a celestial photographer, and has obtained some excellent pictures of the Milky Way and other portions of the heavens, as has also Professor Ritchey of the Mount Wilson Solar Observatory, the work of these two astronomers having recently attracted much attention.

Professor Hale, of the Mount Wilson Solar Observatory, with an instrument he constructed, known as the spectro-heliograph, secured in 1891 the first photograph of the spectrum of a prominence from the surface of the uneclipsed Sun, and he has even photographed successfully the forms of these enormous jets of burning gas, as well as the spots and faculae, or little shining points upon the Sun's surface. These photographs show that the faculae are distributed all over the Sun instead of being near the edge only, and their further study must certainly add much to our knowledge of the Sun's constitution. The number of minor planets or asteroids has been greatly increased during the past decade by photography which is now the only means employed for detecting these bodies, about

700 of them being known at the present time. Four new satellites (three of Jupiter and one of Saturn) have also been discovered by the photographic plate, no telescope in the world having been able to reveal their existence.

An attempt has recently been made to obtain a number of photographs which shall cover the whole extent of the heavens, and the task was one of the most stupendous magnitude. It was necessary to divide the great survey among a number of observatories both in the northern and southern hemisphere, for the work had to include pictures of the immense star-clusters and constellations of the south, which are never visible from this part of the Earth. Some excellent telescopes were especially constructed for this great photographic survey, and we shall soon be in possession of a chart of the entire firmament, embracing millions of stars, each accurately depicted in its exact place upon the celestial vault.

The International Congress on the "map of the sky" held its first meeting at the Paris Observatory on April 20, 1909. The congress is composed of seventy of the leading astronomers from all parts of the world, twenty-two countries having been represented. The congress meets to report on the progress made toward the completion of the famous gigantic map of the sky, which was begun in 1887, and which will not be finished for at least another ten years. On this map there will be marked at least 40,000,000 stars, and photographs taken by all the observatories of the world are being collected.

The value of photographs of celestial phenomena has long been fully recognized by astronomers. But if this art succeeds supplementing human vision, and enables objects to be detected that are far beyond the power of the sense of sight, then may its use in this direction be justly regarded as one of the greatest and most important discoveries of the present century. The possibilities of this new science can hardly be imagined, and while they suggest what is practical, they also turn the mind to what is sublime and poetic, and promise some remarkable material both for pictorial and literary art. We have only touched upon this grand field of research, though it would be interesting to speculate concerning the future revelations of celestial photography, but space will not permit, and we will therefore conclude this article by stating that there are surprising developments of photographic work in the heavens to which we have not even referred.

Battle Creek, Mich.

POWER FROM THE SUN.

ALFRED RORDAME.

The amount of energy continuously poured down upon the Earth by the Sun, which is called the Solar Constant, has been the subject of investigation for over a hundred years. The latest value, 1.92 calories per centimeter-second, adduced by Professor Abbot from investigations carried out at the Astrophysical Observatory of the Smithsonian Institution, is smaller by about one-third than the hitherto-considered correct value given by Professor Langley. This new value may be taken to represent 1 horse-power per square meter of surface, and, as has been stated by Professor Newcomb, the heat of the Sun falling on the deck of a steamer, if it could be utilized by properly constructed machinery, would suffice to propel it across the ocean at a fair rate of speed.

Very early in the dawn of civilization it would likely occur to the student of natural phenomena that some way of using the great heat of the Sun could be arrived at, and we are told that Archimedes, when Syracuse was besieged by the Roman general Marcellus, burned the ships of the enemy by the aid of mirrors reflecting the solar heat. While not authenticated, one can see that this would at least have been possible of accomplishment.

The construction of the first Sun engine we owe to the genius of Captain John Ericsson, one of the greatest inventors of all ages. In a paper published in 1868 he says: "I cannot omit adverting to the insignificance of the dynamic energy which the entire exhaustion of our coal fields would produce, compared with the incalculable amount of force at our command, if we avail ourselves of the concentrated heat of the solar rays. Already Englishmen have estimated the near approach of the time when the supply of coal will end, although their mines so to speak, have just been opened. A couple of thousand years dropped in the ocean of time will completely exhaust the coal fields of Europe, unless in the mean time, the heat of the Sun be employed. "Ericsson's experiments, which extended over a period of 23 years, and which cost him the sum of $100,000, showed that by concentrating, with his apparatus, the rays of the Sun falling upon a surface 10 feet square, he could evaporate

489 cubic inches of water in one hour. This demonstrates the presence of sufficient heat to develop a force capable of lifting 35,000 pounds 1 foot high in a minute, thus exceeding 1 horse power. On July 9, 1875, Ericsson wrote that he had, up to that time, constructed and started seven Sun-motors. In one constructed in 1870 he makes use of a surface condenser, heated by the concentrated solar rays. This has since been patented in a slightly different form by a later inventor. The

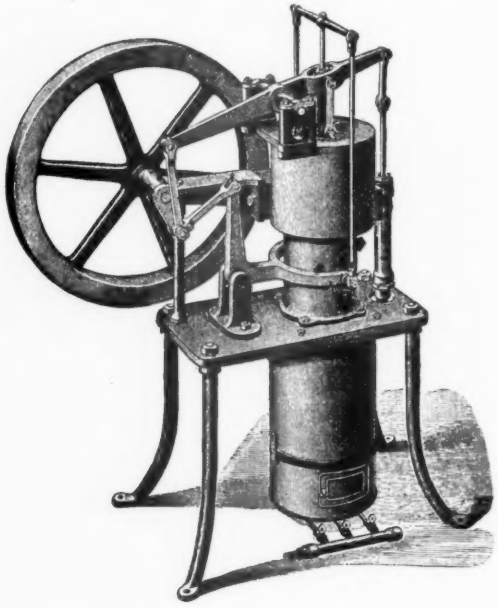


FIG. 1. ERICSSON'S FIRST SUN ENGINE.

illustration, Fig. 1, is a solar engine actuated by heated air. The upper end of the working cylinder was heated by the Sun's rays concentrated upon it by a curved mirror. When thus exposed continuously to the solar heet, the fly-wheel made fully 400 turns per minute. When operated by gas heat, the speed was increased, but no actual gain in power was developed, as ascertained by the friction brake. Ericsson was averse to patenting this small engine as it formed part of his solar apparatus, which he wished to leave as a legacy for the world to use; but in deference to the requests of his business associ-

ates, the inventor reluctantly patented its application to the use of hot air, and without solicitation, gave the patent right to the firm of Delamater & Co., and many thousands were manufactured and sold by them within a few years, and used for pumping water and for other light work. His final engine, which for efficiency has not been surpassed, if equalled by any subsequent inventor, is illustrated in Fig. 2. It consisted of a

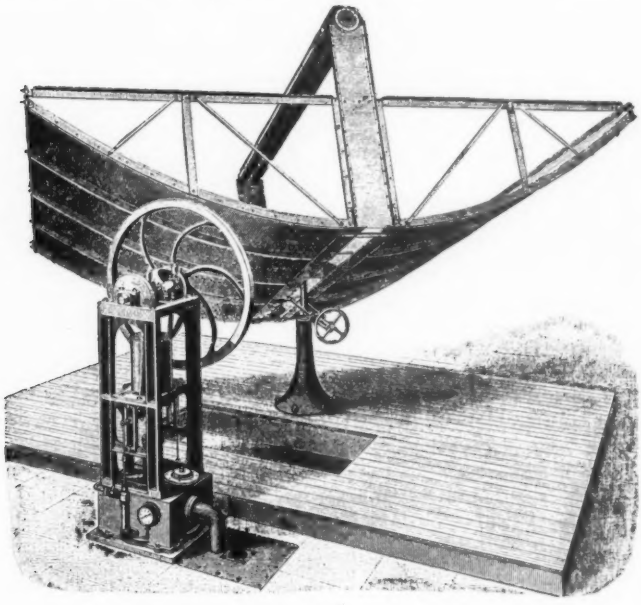


FIG. 2. ERICSSON'S IMPROVED SUN MOTOR.

reflector constructed of a light frame work of wood, made into a parabolic curve, and lined inside with flat panes of silvered window glass. This reflector was 11 by 16 feet. In the focus was an iron tube containing water, which was turned into steam by the heat, and developed fully 3 horse power.

A French inventor, M. Mouchot, had, at the Paris exhibition of 1878, a machine on the grounds of the Trocadero, looking like a gigantic, inverted umbrella pointing sunward. This is illustrated in Fig. 3, and consisted of a great parabolic reflector, which concentrated the heat on a boiler in the focus, and drove a steam engine, which in turn was employed to work a printing press. A little journal, which was called "Le Soleil" (The Sun),

was printed on this and distributed to visitors. In nearly unchanged form this engine has been patented in this country and used at the Ostrich farm, in Pasadena, and other places, for the purpose of pumping water.

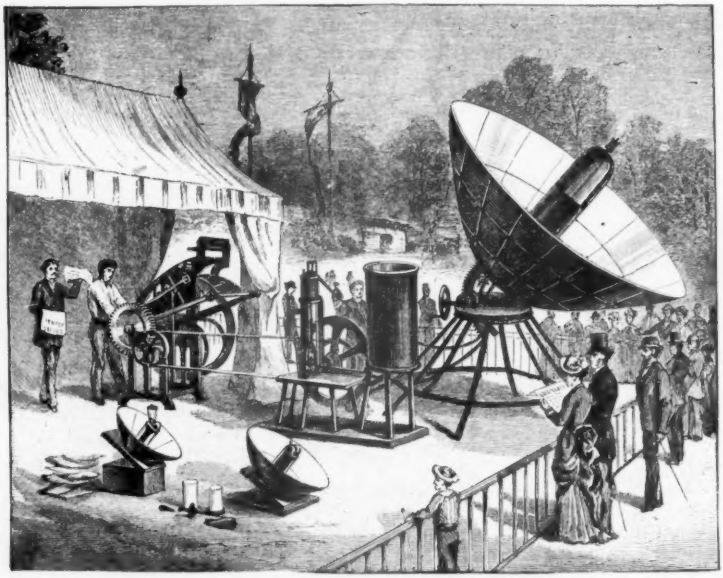


FIG. 3. MOUCHOT'S SUN ENGINE.

The United States Patent Office contains dozens of records of patents granted for the utilization of solar heat, and much ingenuity has been displayed in the construction of the different apparatus, to secure the greatest efficiency. The writer has for a number of years been engaged in trying to solve the problem of the economical transference of heat into electricity, and during these investigations has examined several hundred patents relating to thermo-electricity and kindred subjects, and has come across the following methods of utilizing the heat of the Sun.

In 1888 E. Weston was granted a patent for an apparatus, illustrated in Fig. 4, whereby he concentrated the heat of the solar rays upon the face of a thermopile by a mirror or lens, and, in order to produce absorption of heat energy, he covered the face of the thermopile with lamp black. The current thus obtained, he accumulated in a storage battery, which in turn

drove an electro-motor, whereby the electric current was converted into mechanical energy.

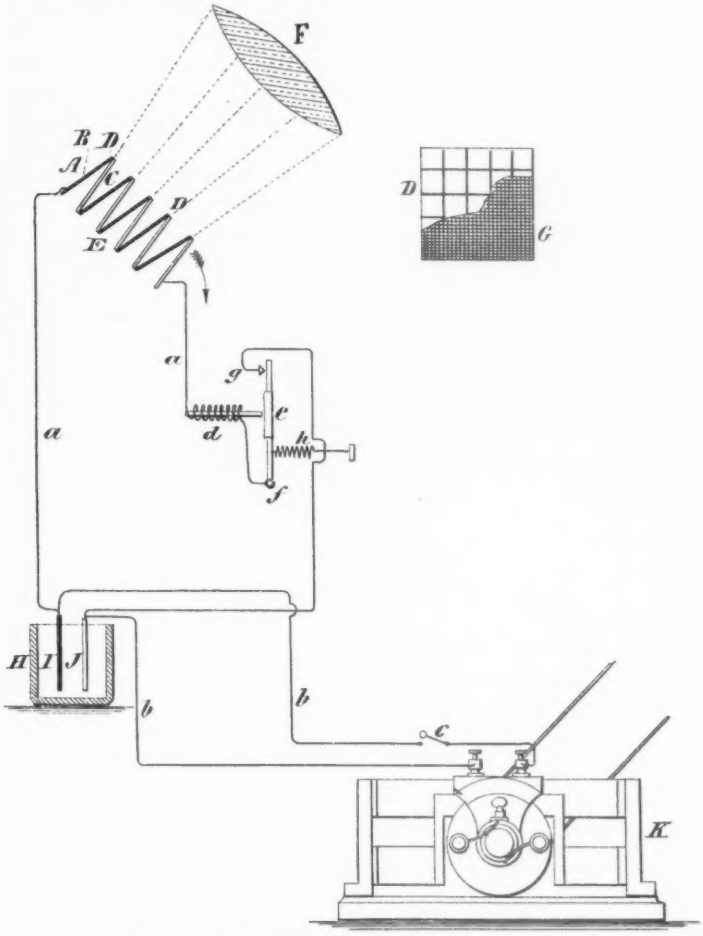


FIG. 4. WESTON'S THERMO-ELECTRIC SUN MOTOR.

In 1893 H. E. Paine patented a solar heater, which is neither more nor less than the old idea of Archimedes, in concentrating the rays of the Sun by means of small plane mirrors on a heat receiver, these mirrors being actuated by clockwork to keep the heat directed to the boiler during the diurnal revolution of the Sun, and also to compensate for the difference of altitude. A more complicated apparatus is hard to imagine.

About the same time, M. L. Severy took out a number of patents, the best of which is a device concentrating the Sun's heat on a steam boiler, driving a motor, which pumps water into a reservoir to operate an auxiliary motor when the first motor stops on cessation of solar heat. He is also patentee of a thermopile arranged upon a circular frame with a revolving commutator, actuated by clock work and exposed to sunlight.

In 1897 H. C. Reagan, Jr., patented the application of solar heat to thermo-electric batteries; the only difference between his and Weston's before-mentioned apparatus, seems to be the application of cold water to one junction of the pile.

W. Calver in 1898 was granted a patent on another most complicated mechanism for the purpose of heating by the solar

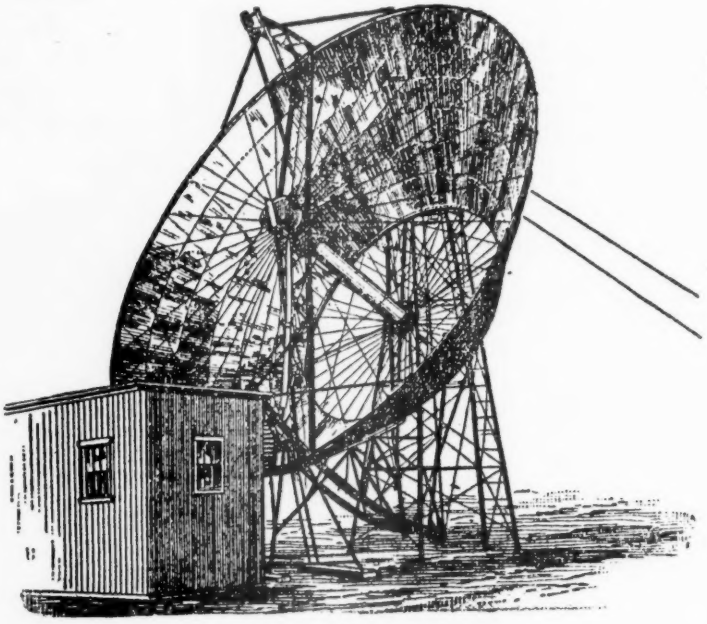


FIG. 5. SUN MOTOR AT PASADENA.

rays. It consisted of a frame carrying a number of mirrors with a boiler mounted on a semi-circular track. In the same year a patent was taken out by Henry F. Cottle on at apparatus for storing solar heat by heating a pile of stones, the heat thus obtained being used to heat a thermopile. J. M.

Browning patented a solar heater in 1904, wherein a casing provided with a transparent cover had its interior formed into a number of chambers, having inclined, reflecting sides, with water receptacles communicating with one another by means of tubes.

The illustration, Fig. 5, shows the solar motor on the Ostrich Farm in South Pasadena, Cal. The mirror, which is modeled after that of Mouchot, is a segment of a paraboloid of revolution 33 feet wide at the top and 16 feet at the bottom. It contains 1788 mirrors, 3½ inches by 24 inches in size. The boiler is tubular, 13 feet 6 inches long, with a capacity for 100 gallons of water and 8 cubic feet additional steam space. The reflector is suspended in the meridian like an equatorial telescope, the boiler being in the focus, and is revolved to follow the Sun by an electric clock, which releases a catch every half minute; and is also furnished with a mechanism to raise or lower the mirror when the Sun is north or south of the equator. The output is 10 horse power for about 8 hours on an ordinary day, and it has pumped water at a maximum rate of 1400 gallons per minute. The mirror area is 70 square yards, and therefore receives 130 horse power of radiation from the Sun and produces 10 horse power, which shows a lower efficiency that Ericsson's engine, having 20 square yards and receiving 35 horse power with an output of 3 horse power.

From 1904 to date, patents for the utilization of solar heat have been granted to several persons but most of them are merely variations of former devices.

F. Shuman, of Philadelphia has constructed a box 60 feet long and 18 feet wide, covered with glass, on the same principle as the hot bed used by florists. In it are laid coils of iron pipe painted black. These pipes are filled with liquid ether, which, being vaporized, is used to drive an engine, and is said to have developed a pressure of 150 lb. The exhaust passes into a condenser after accomplishing its task and is then returned in its fluid state back to the hot box. No detail has been given in any description, so far as I know, of the actual output of work in horse power, and the use of ether seems to have been abandoned and the pipes filled with water in later experiments. The water reached a temperature of 202 degrees, and as is self-evident, steam generated at this temperature even in a vacuum, is capable of doing very little work. The inventor proposes to liquify air with his apparatus and ship it to different places to be used for power. The fallacy of the idea that

liquid air can be used for power has been shown time after time but it perennially crops up again.

Another inventor, Geo. P. Cove, has built a frame, 16 feet square, containing 1804 thermo-couples, each having about one square inch exposed to the rays of the Sun under strips of violet glass, while the other ends of the plugs are sheltered beneath the apparatus. The inventor states that this device developed 2.75 watts to each square foot, or 56 watts in all, when the Sun shines. It seems a preposterous idea to build a complicated mass of metal which must weigh nearly a ton to produce this fraction of a horse power. The chief objection to the thermopile, however, is the fact that by repeatedly heating and cooling off the junctions, they soon deteriorate and loose their electric power, and a pile, which, when first set up, gives 500 watts, or practically one-half horse power, will in the course of a few weeks have decreased its output to about one-sixteenth.

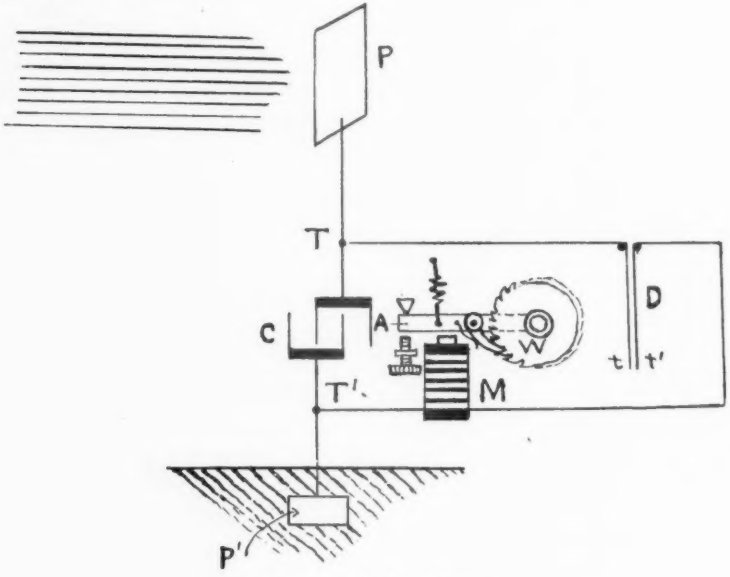


FIG. 6. TESLA'S SUN MOTOR.

Fig. 6 illustrates a device by Tesla, which he calls "apparatus for the utilization of radiant energy." P is a plate exposed to the radiation from the Snn, and P′ a plate buried in the ground. C is a condenser, the plates of which should present

as large a surface as possible. The amount of energy conveyed to it per unit of time will be, according to the inventor, under otherwise identical conditions, proportional to the area exposed. T and T′ are terminals of condenser C. M is a relay magnet or any other device capable of being actuated by an electric current. D may be composed of two very thin conducting plates placed in close proximity, and either by reason of extreme flexibility, or from the character of their support, very mobile.

It will be seen that the magnet M, if energised and deenergised will actuate armature A and, with a pawl and ratchet movement, turn, one step at a time, the wheel W. When the condenser C is charged to a certain potential, the dielectric between the strips will break down, and the condenser discharge its accumulated energy through the magnet M. When the strain on the dielectric has been relieved the strips t t′ will resume their normal position.

H. E. Willsie and J. Boyle, Jr., have lately built an engine in which water, heated by the Sun in a glass-covered receptacle, is made to give up its heat by circulating it about a boiler containing sulphur dioxide. The vapor generated by this heat, after operating an engine, is condensed and returned to the boiler to be used again, while the water which has given up its heat to the SO_2 is sent through the solar heater again to collect more heat from the Sun's rays. Two heaters exposing an area of 1,000 square feet to the Sun are said to have developed a boiler pressure of 215 pounds per square inch, and given 15 horse power. They also give some figures, estimating the cost of such a solar plant at $164 per horse power. The reader can imagine for himself the state of an engine, using sulphurous acid gas, after a few month's run.

We are to-day no nearer the solution of the economical transference of the Sun's heat into work than was Ericsson; indeed, it may be questioned if any subsequent inventor has produced an engine equalling his in efficiency. Future experiments should be made in other directions than those indicated above, and the most promising seems to be a thermo-chemical cell in which the generation of electricity is made by the aid of heat. Such a cell the writer set up two years ago, size 2½ inches by 5 inches, which gives 5 amperes at one volt pressure, at a temperature of 200 degrees F., and which, when the chemical reaction is satisfied, may be perfectly regenerated by letting it cool off. It is absolutely inert at ordinary temperatures. Being hermetically sealed, it works today as energetically as when first set up, and shows an efficiency of about 35% of the heat applied to it.

Salt Lake City, Jan. 15, 1911.

SEEING STARS IN THE DAYTIME.

HAROLD B. CURTIS.

Most people are surprised to learn that Venus can be seen in broad daylight, yet to the amateur astronomer it is no unusual sight. The difficulty is not that the glare of sunlight overpowers the brilliancy of this bright object, for it does not, but that it is hard to find the exact location in the sky. In other words, if you know just where to look, Venus most of the time is plainly visible at noonday. In fact, it was the very pronounced brilliancy of Venus in the clear daytime sky that led the writer to believe that objects less brilliant than Venus could also be seen in daylight, provided it was known just where to look.

As the result of considerable care and patience in looking for the brighter heavenly bodies, the writer at some time or other has succeeded in seeing in daylight, that is, with the Sun above the horizon, the following celestial objects: Jupiter, Mars, Sirius, Capella, Vega and Arcturus.

The circumstances under which Jupiter was seen in the daytime were not at all unusual. Two years ago last fall when Jupiter and Venus were both morning stars and near conjunction with each other, the relative position of the planets with regard to one another was carefully noted early in the morning about an hour and a half before sunrise. Later in the day, between eight and nine o'clock, with the Sun about two hours high, Venus was easily found in the clear blue morning sky just above the roof of a building which shaded the Sun from view. Exactly where Jupiter was supposed to be, surely enough it was, very faint in comparison, but no less certain, beside its much more conspicuous rival. On other occasions too, Jupiter has been picked out of the blue of the evening sky a few minutes before sunset.

It was in this way that Mars was seen during one of its late opposition periods, about ten minutes before sundown. A persistent search in its part of the sky in the southeast was all that was necessary in order to detect it in broad daylight.

Sirius, the brightest of the fixed stars is, naturally, the easiest of its kind to see by daylight. With every early spring the writer amuses himself by picking the Dog Star out of the southern sky on clear evenings just before sunset. A pair of good eyes needs only a fairly accurate knowledge of its location in order to find it.

The circumstances attending the seeing of the three others, Capella, Vega and Arcturus by daylight, were by no means so casual. Vega was seen in the morning sky about five minutes after sunrise. The following simple scheme was resorted to. About half an hour before sunrise, Vega, still plainly visible, was sighted carefully over the topmost branch of a dead tree. It was early June, so Vega was, at this time of day, high in the western sky. As the daylight approached stronger with the consequent dimming of its brightness, the point of light was kept just above the twig. Before it finally faded from the view of recurrent glances, the Sun was already five minutes above the horizon.

Both Capella and Arcturus were seen in the evening sky by the adoption of the same sort of device. The following is the description of how Arcturus was seen. The case of Capella was similar. The star was sighted just above the cornice of a rather tall building about twenty minutes after sunset on a certain evening in spring, the position of observation being carefully noted. By a simple calculation, the writer predicted that the star would lie in line with the same cornice from the same point of observation thirty minutes earlier in the day just one week later in the year. As it was spring, the Sun was still at least ten minutes above the horizon when Arcturus was distinctly visible in the clear blue beyond the cornice.

The ease with which these stars can be seen in the daytime by the normal unaided eye, brings the writer to the opinion that, under favorable circumstances and with the exercise of a little care, other bright first magnitude stars could be found, such as Rigel and Procyon and, for our observers in the southern hemisphere, Canopus and Alpha Centauri.

At a favorable elongation, Mercury's visibility before sunset in the spring and after sunrise in the fall should be unquestioned, but the writer has yet to so observe this fleet Messenger of the Gods.

Barnard College,
New York City, Feb. 4, 1911.

FOUCAULT'S PENDULUM EXPERIMENT.

EDISON PETTIT.

Experimental demonstrations of the truths of astronomy are few and require the use of special apparatus. One of these experiments, without describing which no text-book on astronomy would be complete, is Foucault's pendulum experiment to demonstrate the Earth's rotation. A few directions, it is hoped, will enable many to repeat this classical experiment.

I. The Bob.

The first essential is a heavy, spherical bob of uniform density and having a smooth surface. The question naturally arises as to what shall be the material and size of the bob. It should be as small as its weight permits that the resistance of the atmosphere may not bring the pendulum to rest too soon. This implies the use of a heavy metal, and it is proposed to use lead. For pendulums 10 to 30 feet long, a bob 3 to 4 inches in diameter is needed, and for pendulums 30 to 60 feet long, the bob should be 4 to 6 inches in diameter.

Secure a hollow metallic sphere of the proper size and at a point 90° from the joining place of the two hemispheres of which it is made, bore a hole large enough to allow the sphere to be filled with lead. Such spheres can be secured at a small cost from any scientific company, but they are thin and likely to be dented; the dents should be pushed out with a smooth stick before filling.

The next step is to fill the sphere with lead, but this should not be done by placing the sphere on a table or similar support, as it would be distorted under its own weight. To avoid this, it should be placed in a can and surrounded with sand, which will distribute points of support over the surface. The lead should be heated to a somewhat higher temperature than that necessary for melting and stirred to secure homogeneity of mass; then the sphere should be filled as quickly as possible.

After it has cooled, the lead ball will be found to be slightly loose in the metal sphere. If this sphere is not entirely smooth, it must be ripped off and the lead ball smoothed off, for which purpose a small block plane and sandpaper are efficient tools.

The ball should now be examined to locate the circumference of a circle having the largest diameter. This will usually be

found to be at the place where the two hemispheres were joined. At a point 90° from this circle bore a hole as nearly as possible toward the center large enough to fit the screw of a binding post M (Fig. 1.) The hole should be bored with a black smith's drill, as a hand drill will bind and break in the soft metal.

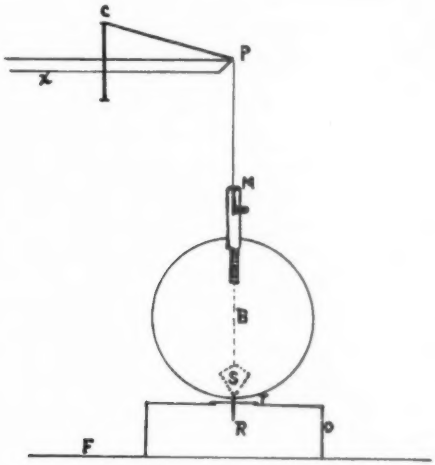


FIGURE 1.

The binding post should go in quite straight although a little inaccuracy may be tolerated.

II. THE POINTER.

While the experiment is in progress it is necessary to have a pointer attached to the bob to mark the deviation of the pendulum. It is obvious that this pointer should mark the continuation of the pendulum wire through the bob. To secure this end we proceed as follows:

From the edge of a table x (Fig. 1.) Suspend a fine plumb-line, PS, and mark the point P, where it touches the table by a small groove. Knock two sides out of a box O, and bore a large hole in the bottom; then tack a thin sheet of metal over this hole. Nail the box O, to the floor F so that the bob s hangs over the metal sheet T. Bring the bob s to rest and with a needle make a hole in the metal plate T, directly beneath the bob. Remove the small plumb-line and by means of a fine piano wire attached to the binding post M, suspend the lead ball B, in its place from the point P, holding the wire by a wood clamp c, so that the ball is only a millimeter or so

above the metal plate T. Bring the ball to rest and insert the needle R, in the hole from beneath and punch it into the lead ball. This is the place where the pointer is to be attached to the ball.

A convenient shape of pointer is P, (Fig. 4), made of soft steel, although a small pointed rod of any material will do. Bore a hole at the point determined and insert the pointer. Now suspend the ball and pointer again from the point P on the table as in (Fig. 1), and adjust it so that the pointer is just above the metal plate. If the pointer does not come directly over the needle hole, knock it to one side until it does, then screw it in firmly. When finally adjusted the pointer should point directly at the needle hole. If the metal sphere has been ripped off the lead ball should now be painted with aluminum paint containing an excess of varnish to give it a smooth surface.

III. The Suspension Wire and Support.

The wire should be piano wire and as small as will support the bob. For smaller pendulums about 28 gauge is sufficient and for larger 20 to 25 gauge should be used; this wire should be

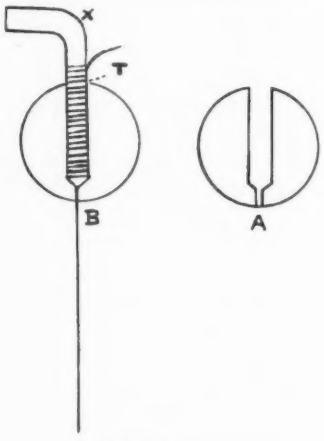


Figure 2.

polished and oiled. The support must be rigid as flexure would be fatal to results. Secure a tripod-base T, (Fig. 4), from a laboratory support and through each of the feet bore a hole A, to admit a wood screw. From the underside enlarge the rod-hole so that it will admit a small brass ball B, leaving a

part of the aperture the original size, so that the ball will not go entirely through. Thread this enlarged portion and make a set-screw s to fit it so that this may be screwed down on ball B.

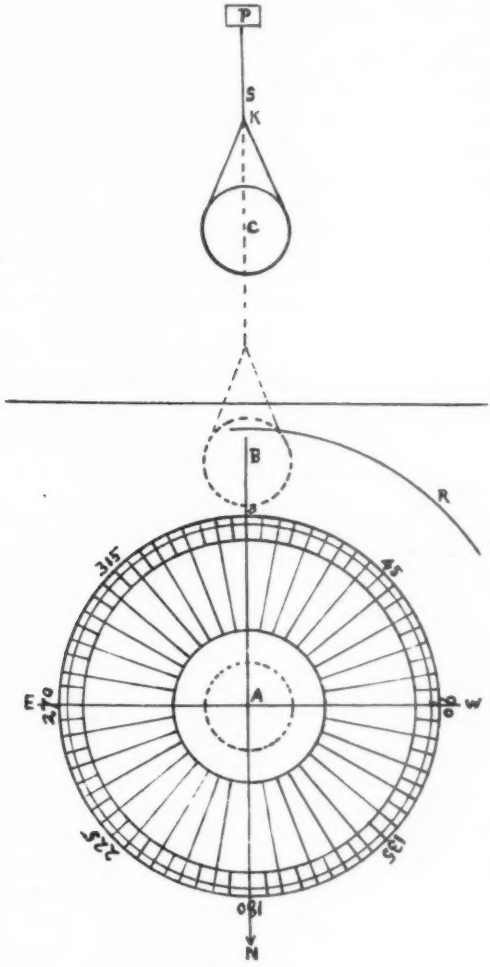


FIGURE 3.

The ball B should be a small brass knob of the kind used on electrical apparatus. It will now be necessary to fasten the wire to this ball. The boring of such a ball is shown at

A, (Fig. 2). Thread the larger hole and make a set-screw x of brass to fit it. Make a file-mark up one side of this set-screw just deep enough that the wire may be laid in it. Insert the wire through the small hole of the ball, lay it in the groove of the set-screw and while holding it in this position screw it tightly into the ball B. Cut off the set-screw at T and smooth it down. Soak the ball B in zinc chloride; then dip it into molten solder to fill up all the spaces and unite the whole.

IV. The Graduated Dial.

On a piece of stiff paper lay off a circle (Fig. 3), divide it into degrees and mark the cardinal points. By means of thumb-tacks fasten this circle to a board.

V. Erecting the Pendulum.

The pendulum may be installed in the class room or any-

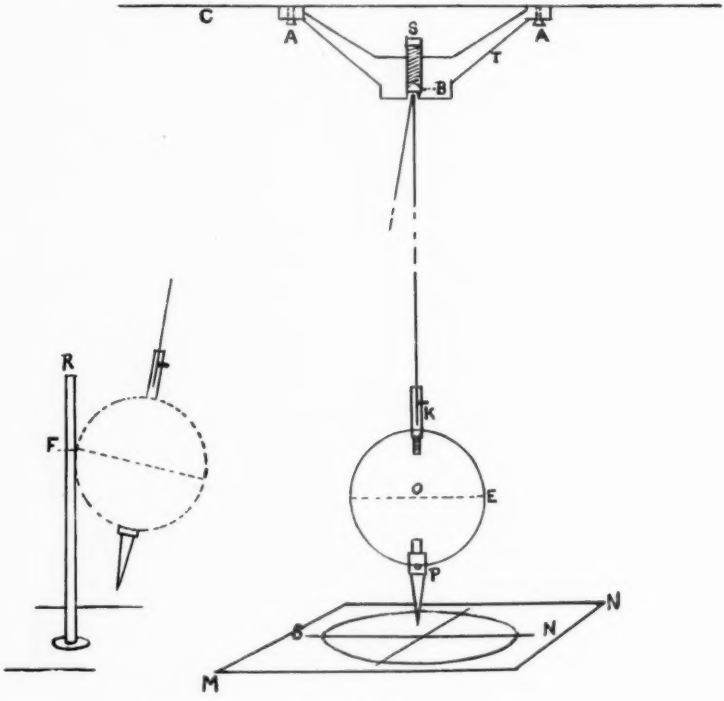


FIGURE 4.

where that the drop is sufficient and it should be protected from air-currents and jars. Screw the tripod T, (Fig. 4), to the ceiling,

attach the wire and bob O, as shown. Bring the circle and board MN, directly beneath the bob, on the floor, so that the pointer P, is directly over its center x. Level this board by means of small wedges; then nail it to the floor by a single nail through x, having adjusted it so that the meridian line NB is approximately in the meridian. At some distance from x in the NB direction erect a convenient standard R, so that it shall be very rigid. Locate the equator E of the ball O, with reference to K and P, as poles, and mark it with a knife-scratch. Now screw the set-screw s down on the ball B, then pull the bob O to the standard R, and mark on R the point F where the equator nearly touches it.

Prepare a cotton string like s, (Fig. 3,) with a loop that is much larger than necessary to go round the ball. Attach the string at F, to the standard R, (Fig. 4), and place the loop around the bob so that it lies in the equator E, while the bob hangs over x. Keeping the chord at F, pull the bob back so that it takes the position B, (Fig. 3). Now if the meridian mark NB passes through P, the pointer of the bob will be over the meridian at B, but as this is not likely it is necessary to rotate the board about the nail through A until the meridian NB comes under the pointer. Since A did not move, then if the string were cut, the bob would begin to vibrate so that the pointer would be above NB during the whole vibration. Pull the pendulum back so that when the string is broken the entire arc, which it will describe, will be about 15° and tie it firmly at F to the post R, (Fig. 4), the bob having some such position as C, (Fig. 3), and allow it to remain thus several hours before the experiment begins.

A ridge of fine sand may be placed on the board, in a position similar to R, (Fig. 3), just high enough that the pointer may cut it in passing.

VI. The Experiment.

When the apparatus has been set up, the string s, (Fig. 3), is burned somewhere between K and P, setting the pendulum in motion, so that at the first stroke its pointer will describe the line BN, while the loop around the ball drops off. After a few moments however, the direction of the swing of the pendulum will be seen to shift gradually toward the NE-SW direction, as shown by the arrow R.* The amount of shift θ, for any length of time τ is given by the formula

$$\theta = \tau\, 360° \sin \phi$$

where τ is expressed in days and ϕ is the latitude of the place. If the apparatus is carefully constructed the pendulum will obey this law very closely.

* It will shift in the opposite direction in the southern hemisphere.

Peru, Nebr., State Normal School.
Jan. 21, 1911.

THE NATURE OF "CORONIUM" IN SUN AND STAR.

MONROE B. SNYDER.

The theory of explosive radio-activity at critical physical states in the stars, which I have termed "radio-action," led me more than a year ago to a final proof of the nature of the hitherto unknown "coronium" of the solar corona. The announcement of this discovery would have entailed too much reference to novel and complex theory to permit of brevity, and it was hence withheld. It is now, however, possible to refer to the conclusion reached without discussion of the process used.

Professors Adams and Gale,* of the Mount Wilson Solar Observatory, have recently said: "An attempt was made to identify the coronal line at λ 5303.26$\pm$15; the photographs (of the chromosphere) show a well marked line at λ 5303.36, but it is probable that this line is coincident with the dark line at λ 5303.401 in Rowland's Tables." I find it necessary, therefore, to state that this "well-marked" chromospheric line at λ 5303.36 is due to "alpha hydrogen," as I name the "many-lined" hydrogen series, which has a line at λ 5303.35, of well marked intensity; and that both this chromospheric line and the alpha hydrogen line mentioned are identical with the main coronal line. This is not a case of accidental coincidence, for, quite apart from this identity of wavelength, the radio-active evidence for the inference had already, as stated, become absolutely conclusive. At least seven of the brightest lines of the solar corona luminesce in the self-same alpha hydrogen.

It should also be noted that Professor Campbell† in assigning the wave length 5303.26 to the coronal line in 1898, made the following significant remark: "However, the above value of the wave length should not be in error by more than $\pm$0.15 t. m." and that this estimate has proved to be strictly accurate. The actual error of that measurement is now found to be only about $\pm$0.09. Evershed's measurement of λ 5303.3, to which unfortunately no probable error was assigned, is also seen to be in good agreement.

Moreover, Dr. Walter S. Adams, in the same issue of "Science" says concerning his work on Campbell's famous star of the

* *Science*, Dec. 16, 1910, p. 881.

† *Astrophysical Journal*, Vol. X. p. 191.

hydrogen envelope, D. M. + 30° 3639: "The bright line at λ 4068 also extends outward about 4″; the origin of this line is unknown. This is also true of the extremely bright band at λ 4652 which does not extend beyond the continuous spectrum." I would point out that the bright line at λ 4068 is the double line of alpha hydrogen at λ 4067.05 and λ 4069.80, each of the intensity 6; and that this statement can be verified in several ways; especially by photographing the star's spectrum with higher dispersion. I have finally also to indicate that "The extremely bright band at λ 4652 is due to xenon.

The Wolf-Rayet stars, of which Campbell's star of the hydrogen envelope is so notable, were indeed the first stars in which the radio- active character of the spectra became plainly evident to me, six years ago. And although their general light may scarcely vary, it is certain that their spectra do vary, and that this variation is traceable to radio-action.

Alpha hydrogen, or "coronium hydrogen," as it may now well be called, is thus, as one of the products of radio-active transformation, found to luminesce in the vast radio-spheres about Sun and star, and there to demonstrate the balanced play between the forces of radio-action and gravitation.

Philadelphia Observatory, Jan. 3, 1911.

THE TOTAL SOLAR ECLIPSE OF 1911 APRIL 28.

DR. PIO EMANUELLI.

This article, written by the secrectary of the Vatican Observatory, comes to hand too late to be of use to parties intending to observe the eclipse, but will be of interest to others in showing how few places there are and what sort of places they are, from which the total phase of the eclipse can be observed. As shown by the chart in our January number, the path of totality is almost wholly over water, touching land only at a few small islands. Owing to the extreme improbability of good weather conditions on these islands, American astronomers, so far as we have learned, have organized no expeditions to observe this eclipse.

This total solar eclipse is visible in the Pacific ocean and is interesting for its duration of totality, which can reach $4^m\ 57^s$ at a point in the Pacific Ocean. The path of the Moon's shadow will pass over three archipelagos, those of Tonga, Samoa and Union.

In the archipelago of Tonga the best place to observe the eclipse is Vavau Island.* From the *Sailing Directions, Pacific Islands*, which is a publication of the *Hydrographic office* in London we take the following geographical particulars:†

"Vavau Island is the principal island of the Vavau group. It is nearly 9½ miles in length, east and west, with an extreme breadth from north to south of 6¾ miles, and is very irregular in shape on its southern side. The north-west, north, and north-east coasts are bounded by cliffs from 600 to 200 feet high, the faces of which are generally covered with vegetation, with landslips here and there showing in large white patches, and there is no fringing reef except round the small indentations on the north east coast.

The island is of upraised coral formation, presenting a remarkable appearance from the westward; the north-western side is cultivated up to a height of 670 feet and slopes to the south-eastward. There is a conspicuous flat-topped hill, named Moungalafa, 610 feet high, at the south-west end of the island, the top of which falls steeply on all sides, showing as a prominent feature, and Talau is another conspicuous hill visible from the southward, 430 feet high, and occupying the western end of a promontory westward of Neiafu anchorage.

To the north-east of Moungalafa lies the lagoon, shallow at its eastern end, but very deep at the western end. Ducks are

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* Prof. Moors, of *British Astronomical Association* (New South Wales Branch), has indicated as another observing station Tofua island, of Tonga group. which is an active volcano and high. "Tofua island, situated westward of Haapai group, and separated from it by a deep channel 15 miles wide is an active volcano and appears flat topped from the sea. It is 5¼ miles long in a north and south direction by 3¾ miles broad with a steep cliffy coast line almost throughout. The hills, from 1500 to 1645 feet in height, rise steeply from the coast except on the northwest side where the slope is more gradual, forming the walls of a large crater which occupies the center of the island, at the bottom of which there is a remarkable fresh water lake. Smoke was seen in 1898 to be issuing from a vent at the north-west end of the lake.

Tofua
$\lambda = -175° 5'$ $\phi = -19° 45'$

	Local mean time April 27.				Angle from north point	Angle from vertex
First contact	20^h	20^m	$44^s.9$		$231°$	$352°$
Totality begins	21	30	9 .2	$\tau = 3^m 38^s.8$	51	183
Totality ends	21	33	48 .0		228	1
Last contact	22	51	1 .4		49	203

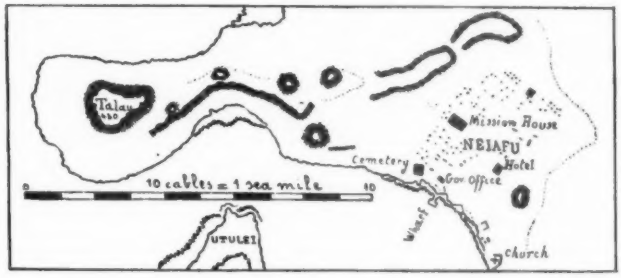
† *Admiralty Sailing Directions, Pacific Island*, Vol. II (Central groups) p. 62-64.

plentiful. Numerous villages are scattered over the island, connected by turf roads, and a road runs round the northern coast along the edge of the cliffs for the greater part of the way.

The population of the whole group is estimated at 3,500, of whom the greater number are resident on Vavau, and the remainder are distributed amongst the other larger islands.

The most suitable place on Vavau island for an observing station is the town of Neiafu.

Neiafu, situated on the southwest coast of Vavau, one mile eastward of Talau hill, is the port of call in the Vavau group for the mail steamers, which call here from Sydney every four weeks. The Governor of the group resides here, and it is the headquarters of some English and German trading firms. The Government offices are close to the landing place.



PLAN OF NEIAFU AND ITS ENVIRON

The calculation of the phases for the town of Neiafu was made by Dr. A. M. W. Downing with the data of *Nautical Almanac*, and published in *Monthly Notices*.* It is to be noted that, with existing errors of the lunar tables, the times of contacts are, in each case, several seconds too late.

Neiafu † $\lambda = -173° 59'$ $\phi = -18° 39'$

	Local mean time April 27				Angle from north point	Angle from vertex
First contact	20^h	26^m	47^s		230°	350°
Totality begins	21	37	1.7	$\tau = 3^m\ 36^s.8$	36	169
Totality ends	21	40	38.5		242	15
Last contact	22	58	48.		49	203

From this it will be seen that totality will last $3^m\ 37^s$. The Sun's altitude and azimuth (from N) at the time of totality

* *The Total Solar Eclipse of 1911 April 28.* By A. M. W. Downing D. Sc., F. R. S. MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY Vol. LXIX, No. 1, Nov. 1908, p. 30-32.

† (North latitude and east longitude are considered positive.)

are respectively: 43°, 49°.

The following is an abstract from a table compiled by the *Meteorological Office* in London from observations made at Neiafu during the years 1890-91; the table is published in the volume of *Sailing Directions* referred to above.

Month	Barometer reduced to 32° and sea level	Temperature		Rain			Wind at 9 A.M.									
							Average force Beaufort	Number of Days from								
	Mean Height 9. A. M.	Mean Max.	Mean Min.	Total Fall	No. of Days	Max. fall in 24 hours		N	N.E	E	S. E.	S	S.W.	W.	N.W	Calm
	Ins.			Ins.		Ins.										
Mar.	29.94	84°	74°	20.85	21	9.45	3	5	3	6	11	1	1	3	0	1
Apr.	29.96	85	73	9.24	18	3.51	4	1	5	4	13	2	0	4	0	1
May	30.03	83	71	3.04	9	1.86	4	1	2	5	16	4	0	2	1	0

This meteorological data may be useful to observers, as affording an indication of the probable weather conditions at the time of the eclipse.

According to reports that we have received there seem to be three expeditions to observe the eclipse from Vavau Island.

1 The one of the English government, directed by Rev. F. A. L. Cortie, S. J. of *Stonyhurst* Observatory.

2 The one directed by Mr. F. K. McClean of *Tunbridge Wells*.

3 The one by Mr. J. H. Worthington of *High Wycombe*.

In the archipelago of Samoa the best place for observation is Tau Island.

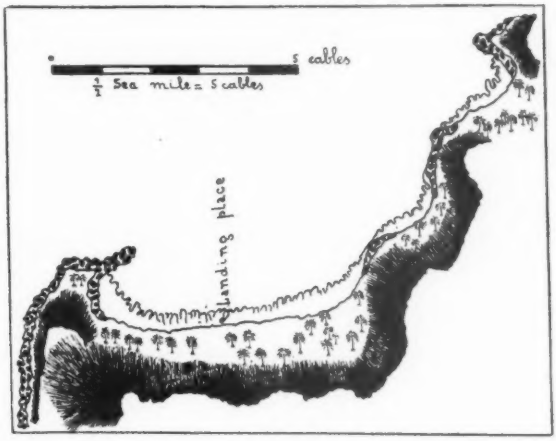
Tau island, the largest of the Manua group, is in the form of a dome, rising to the height of 2,500 feet; it is about 14 miles in circumference, and covered with a luxuriant vegetation, and has many cocoanut groves on its north-west side. The principal village, named Tau, is on the west side of the island, where there is an anchorage near the shore with a cove for landing.

The calculation of the phases was made by Bessel's method with the data of the *American Ephemeris*; it refers to the Faleasau bay, the coördinates of which are:

Faleasau bay (Tau Is.)
$\lambda = -169° 32'.0$ $\phi = -14° 13'.5$

	Local mean time April 27				Angle from north point	Angle from vertex
First contact	20h	52m	26s.3		228°	348°
Totality begins	22	6	53 .6	$\tau = 2^m 13^s.0$	351	126
Totality ends	22	9	6 .6		285	60
Last contact	23	31	34 .1		49	216

So far as we know, no meteorological observations were ever made at Tau island. In the Upolu island, of this archpelago there is an observatory erected in Apia . The investigation of meteorological observations made at the Apia observa-



TAU Is.

tory during 15 years (1890-1904) and published in the *Sailing Directions* leads to the conclusion that, at the end of April, in the Samoa archipelago, generally, in every 12 days there are 7 with rain fall.

In the Union archipelago the most suitable place for observation appears to be Nassau Island.*

Nassau island, also visited by H. M. S. *Pylades* in September,

* Dr. W. J. S. Lockyer in an article published in *Nature* of London indicates also as an observing station, Danger Islands which belong to this archipelago. The reef of Danger Islands is thus described in the *Sailing Directions*;

"The reef generally is extremely dangerous, both on account of its extent, and of the strong current that sets westward on it. The lagoon is shallow with many dry patches, and has no entrance even for canoes; there is deep water, close to it on the outside. The only landing place (and that generally an impossible one for ship's boat) is on the western side of Puka Puka.

Danger Is. $\lambda = -165° 45'$ $\phi = -10° 53'$

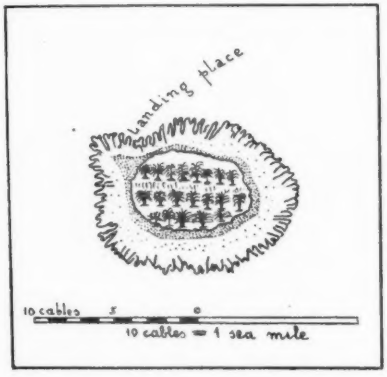
	Local mean time April 27-28				Angle from north point	Angle from vertex
First contact	21^h	15^m	20^s.2		227	347
Totality begins	22	32	14 .6	$\tau = 3^m\ 19^s.4$	8	146
Totality ends	22	35	34 .0		266	46
Last contact	0	0	11 .0		48	230

1899, was discovered in 1835 by an American whaler of that name, 45 miles south-eastward of the Danger Islands; it is 7 cables in extent east and west by 5 cables wide, and is surrounded by a fringing reef outside of which no dangers can be seen. The island was anexed to Great Britian at the same time and by the same officer as were the Danger Islands. It is now a dependency of the Dominion of New Zealand.

The island has good soil, and might produce many more cocoanut, banana, and other trees than at present; its highest part is at least 70 feet above the sea. The few inhabitants depend on the visits of trading schooners for provisions; but they have plenty of good water. Bread-fruit, banana, taro, cocoanut and lime trees all grow on this island.

The best landing place is on the northern side of the north-western point, but even with a smooth sea, a boat from H. M. Surveying-vessel *Alert* was unable to effect a landing, the swell was so great, though Commander Tupper, in 1899, thinks he could have accomplished it in a ship's whaler had a surf boat not been available.

In 1899, the inhabitants consisted of only half a dozen natives



NASSAU ISLAND (MOTUGAUGAU.)

who collect and ship copra for the lessee of the island.*

For this island also the calculation of the phases was made by Bessel's method with the data of the *American Ephemeris*. The position adopted is that of the northern point of the island.

* *Admiralty Sailing Directions*, Pacific Islands, Vol. III (Eastern groups) p. 188.

Nassau Is. $\lambda = -165° 25'$ $\phi = -11° 33'$

	Local mean time April 27-28				Angle from north point	Angle from vertex
First contact	21^h	16^m	$11^s.4$		228°	349°
Totality begins	22	32	41 .7	$\tau = 4^m 9^s.9$	62	201
Totality ends	22	36	51 .6		214	355
Last contact	0	1	2 .5		47	229

From computation of the phases, it will be seen that the duration of the total eclipse is very remarkable. It is hoped that this notable totality will be utilized by some astronomical expedition for the study of solar physics. The Sun's altitude at the time of total eclipse will be 57°.

It seems that no meteorological observation was ever made in Nassau island, but from investigation of atmospheric conditions of some places near the Union archipelago, we are able to say that perhaps in Nassau Island rainy days are much less frequent than in Tonga and Samoa islands.

Rome, Dec. 21, 1910.

PLANET NOTES FOR APRIL, 1911.

Mercury will be in perihelion on April 2. It will reach its greatest heliocentric latitude north on April 12, and will reach its greatest elongation east on April 14. On this date it will set approximately one hour and fifteen minutes after the Sun, and may possibly be seen low in the twilight.

Venus will be at perihelion on April 29. It will set from two hours to two hours and a half after the Sun during the month and will be quite conspicuous in the western sky. It will be the bright evening star and will far exceed any star in that part of the sky.

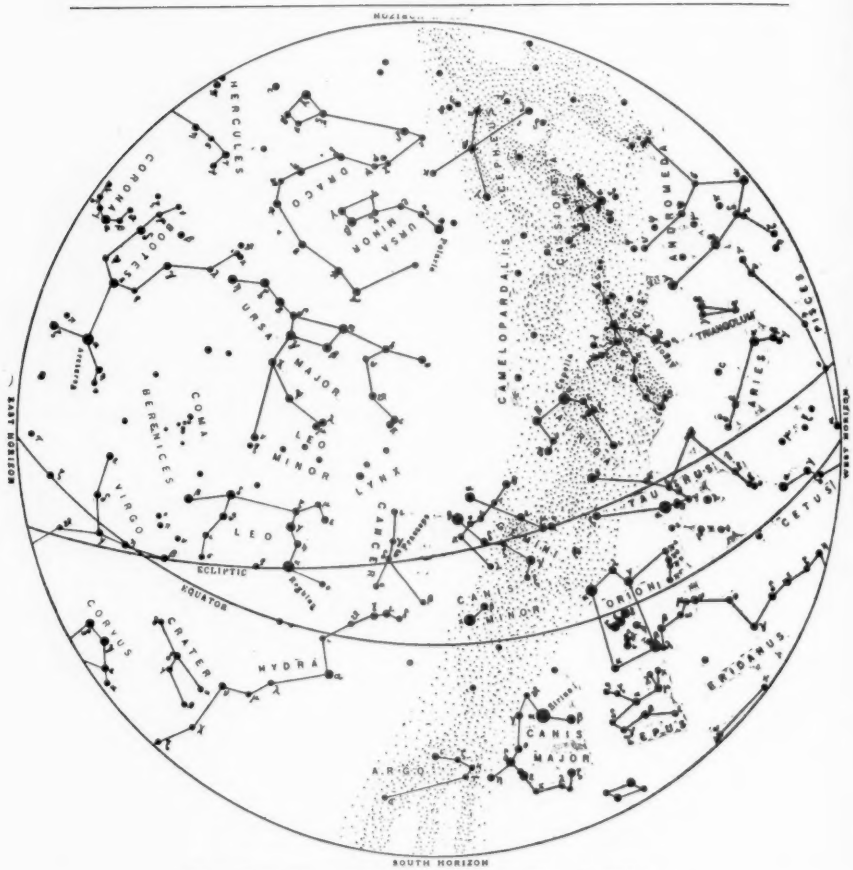
Mars will rise three or four hours before the Sun. It is approaching the the Earth again and is becoming brighter. It may be recognized as a bright star in the morning sky.

Jupiter will continue to rise earlier in the evening, and on April 30 will be at opposition, at which date it will rise at sunset. It will then be a conspicuously bright object in the eastern sky in the evening.

Saturn will be visible low down in the western sky just after sunset in the early part of the month. On April 30 it will be in conjunction with the Sun and will then be invisible for a few months until it reappears in the east before sunrise.

Uranus will be in quadrature, 90° west of the Sun, on April 19. It will be visible in the southeastern sky in the early morning and will be on the meridian at an altitude less than 30°.

Neptune will be in quadrature, 90° east of the Sun, on April 9. It will cross the meridian about sunset. It may be found in the constellation Gemini



THE CONSTELLATIONS AT 9:00 P. M., MAR. 1, 1911.

Occultations visible at Washington.

Date 1911	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N °	Duration h m
Mar. 5	53 Arietis	6.0	6 37	86	7 45	289	1 9
9	47 Geminorum	5.6	4 52	74	6 5	282	1 13
9	134 BGeminorum	6.5	7 57	102	9 20	276	1 23
11	90 H′ Cancri	6.1	5 34	85	6 40	303	1 7
12	η Leonis	3.6	5 6	70	5 56	325	0 50
18	*i* Librae	4.3	20 1	164	20 38	229	0 37
21	163 G Ophiuchi	6.3	18 31	99	20 2	267	1 30
Apr. 1	124 B Arietis	6.4	8 17	118	8 54	209	0 38
3	*k* Tauri	5.6	10 17	128	10 57	227	0 40
6	ω' Cancri	6.0	6 19	130	7 34	259	1 16
12	θ Virginis	4.6	8 57	113	10 12	326	1 15
15	147 B Librae	6.2	9 54	95	10 58	328	1 4
16	19 Scorpii	4.9	10 11	72	11 0	342	0 49
16	22 Scorpii	4.8	16 52	71	18 5	312	1 13
18	48 G Sagittarii	6.3	17 48	60	19 8	291	1 20
21	86 B Capricorni	6.2	14 17	60	15 27	280	1 10

Phenomena of Jupiter's Satellites.

Central Standard Time.

1911	h	m			
Feb. 1	15	21	I	Ec.	Dis.
2	12	27	I	Sh.	In.
	13	41	I	Tr.	In.
	14	39	I	Sh.	Eg.
	15	53	I	Tr.	Eg.
3	13	13	I	Oc.	Re.
4	17	36	II	Ec.	Dis.
5	16	35	III	Sh.	In.
6	12	42	II	Sh.	In.
	15	12	II	Tr.	In.
	15	20	II	Sh.	Eg.
8	18	15	I	Ec.	Dis.
9	11	58	III	Oc.	Dis.
	13	9	III	Oc.	Re.
	14	20	I	Sh.	In.
	15	34	I	Tr.	In.
	16	32	I	Sh.	Eg.
10	15	6	I	Oc.	Re.
11	12	14	I	Tr.	Eg.
13	15	16	II	Sh.	In.
15	14	27	II	Oc.	Re.
16	12	17	III	Ec.	Re.
	15	53	III	Oc.	Dis.
	16	13	I	Sh.	In.
	16	58	III	Oc.	Re.
	17	26	I	Tr.	In.
17	13	26	I	Ec.	Dis.
	16	57	I	Oc.	Re.
18	11	54	I	Tr.	In.
	12	54	I	Sh.	Eg.
	14	5	I	Tr.	Eg.
19	11	25	I	Oc.	Re.
22	12	3	II	Ec.	Dis.
	16	57	II	Oc.	Re.
23	14	46	III	Ec.	Dis.
	16	14	III	Ec.	Re.
24	12	0	II	Tr.	Eg.
	15	29	I	Ec.	Dis.
25	12	35	I	Sh.	In.
	13	44	I	Tr.	In.
	14	47	I	Sh.	Eg.
	15	55	I	Tr.	Eg.
26	13	15	I	Oc.	Re.
Mar. 1	14	37	II	Ec.	Dis.
3	11	54	II	Tr.	In.
	12	18	II	Sh.	Eg.
	14	26	II	Tr.	Eg.
4	14	28	I	Sh.	In.
	15	34	I	Tr.	In.
	16	40	I	Sh.	Eg.
5	11	50	I	Ec.	Dis.
	15	4	I	Oc.	Re.
6	11	9	I	Sh.	Eg.
	12	12	I	Tr.	Eg.
	13	10	III	Tr.	In.
	14	1	III	Tr.	Eg.
10	12	14	II	Sh.	In.
	14	17	II	Tr.	In.
	14	51	II	Sh.	Eg.
	16	49	II	Tr.	Eg.
Mar. 11	16	21	I	Sh.	In.
12	11	2	II	Oc.	Re.
	13	44	I	Ec.	Dis.
	16	52	I	Oc.	Re.
13	10	50	I	Sh.	In.
	11	49	I	Tr.	In.
	12	24	III	Sh.	In.
	13	2	I	Sh.	Eg.
	14	0	I	Tr.	Eg.
	14	6	III	Sh.	Eg.
	16	48	III	Tr.	In.
14	11	18	I	Oc.	Re.
17	14	47	II	Sh.	In.
	16	39	II	Tr.	In.
19	13	25	II	Oc.	Re.
	15	37	I	Ec.	Dis.
20	12	43	I	Sh.	In.
	13	36	I	Tr.	In.
	14	56	I	Sh.	Eg.
	15	47	I	Tr.	Eg.
	16	22	III	Sh.	In.
21	10	5	I	Ec.	Dis.
	13	5	I	Oc.	Re.
22	9	24	I	Sh.	Eg.
	10	13	I	Tr.	Eg.
24	10	14	III	Oc.	Dis.
	10	56	III	Oc.	Re.
26	11	40	II	Ec.	Dis.
	15	44	II	Oc.	Re.
27	14	37	I	Sh.	In.
	15	22	I	Tr.	In.
28	9	15	II	Sh.	Eg.
	10	39	II	Tr.	Eg.
	11	58	I	Ec.	Dis.
	14	51	I	Oc.	Re.
29	9	5	I	Sh.	In.
	9	49	I	Tr.	In.
	11	17	I	Sh.	Eg.
	11	59	I	Tr.	Eg.
30	9	17	I	Oc.	Re.
31	10	35	III	Ec.	Dis.
	11	59	III	Oc.	Re.
	13	40	III	Oc.	Dis.
	14	20	III	Oc.	Re.
Apr. 2	14	16	II	Ec.	Dis.
4	9	11	II	Sh.	In.
	10	24	II	Tr.	In.
	11	48	II	Sh.	Eg.
	12	56	II	Tr.	Eg.
	13	52	I	Ec.	Dis.
5	10	59	I	Sh.	In.
	11	35	I	Tr.	In.
	13	11	I	Sh.	Eg.
	14	45	I	Tr.	Eg.
6	8	20	I	Ec.	Dis.
	11	2	I	Oc.	Re.
7	8	11	I	Tr.	Eg.
	14	33	III	Ec.	Dis.
	15	56	III	Ec.	Re.
11	11	45	II	Sh.	In.

1911	h	m				1911	h	m			
Apr. 11	12	40	II	Tr.	In.	Apr. 20	12	7	I	Ec.	Dis.
	14	22	II	Sh.	Eg.		14	30	I	Oc.	Re.
	15	11	II	Tr.	Eg.	21	9	16	I	Sh.	In.
	15	45	I	Ec.	Dis.		9	30	I	Tr.	In.
12	12	53	I	Sh.	In.		11	28	I	Sh.	Eg.
	13	19	I	Tr.	In.		11	40	I	Tr.	Eg.
	15	5	I	Sh.	Eg.	22	8	56	I	Oc.	Re.
	15	30	I	Tr.	Eg.	25	12	13	III	Sh.	In.
13	9	32	II	Oc.	Re.		13	7	III	Tr.	In.
	10	13	I	Ec.	Dis.		13	52	III	Sh.	Eg.
	12	46	I	Oc.	Re.		13	54	III	Tr.	Eg.
14	7	45	I	Tr.	In.	27	11	23	II	Ec.	Dis.
	9	34	I	Sh.	Eg.		14	1	I	Ec.	Dis.
	9	56	I	Tr.	Eg.		14	4	II	Oc.	Re.
18	8	14	III	Sh.	In.	28	11	10	I	Sh.	In.
	9	52	III	Tr.	In.		11	14	I	Tr.	In.
	9	54	III	Sh.	Eg.		13	22	I	Sh.	Eg.
	10	35	III	Tr.	Eg.		13	24	I	Tr.	Eg.
	14	18	II	Sh.	In.	29	8	29	I	Ec.	Dis.
	14	54	II	Tr.	In.		8	45	II	Sh.	Eg.
19	14	47	I	Sh.	In.		8	46	II	Tr.	Eg.
	15	4	I	Tr.	In.		10	39	I	Oc.	Re.
20	8	46	II	Ec.	Dis.	30	7	50	I	Tr.	Eg.
	11	48	II	Oc.	Re.		7	51	I	Sh.	Eg.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

COMET NOTES.

Ephemeris of Faye's Comet 1910 *c*.—The following ephemeris, published in *A. N.* 4469, was computed by M. Ebell at Kiel, from elements published in the Lick Bulletin, No. 187.

1911		α True h	m	s	δ True °	′	log *r*	log Δ
Mar.	1	5	4	32	+10	7.6	. .	. .
	2		6	14	10	13.9		
	3		7	56	10	20.2	0.3086	0.2307
	4		9	39	10	26.3		
	5		11	22	10	32.4		
	6		13	5	10	38.4		
	7		14	49	10	44.3	0.3131	0.2458
	8		16	33	10	50.1		
	9		18	18	10	55.8		
	10		20	3	11	1.4		
	11		21	49	11	7.0	0.3176	0.2607
	12		23	35	11	12 4		
	13		25	21	11	17 8		
	14		27	7	11	23.0		
	15		28	54	11	28.2	0.3222	0.2752
	16		30	41	11	33.2		
	17		32	28	11	38.2		
	18		34	15	11	43.2		
	19		36	3	11	47.7	0.3268	0.2894
	20		37	50	11	52.3		
	21		39	39	11	56.8		
	22		41	27	12	1.2		
	23		43	16	12	5.5	0.3313	0.3032
	24		45	5	12	9.7		
	25		46	54	12	13.8		
	26		48	43	12	17.7		
	27	5	50	33	+12	21.6	0:3358	0.3168

Ephemeris of Comet Wolf:—The following ephemeris of Comet Wolf for March was computed by Mr. M. Kamensky at Libau and was published in *A. N.* 4465.

1911	α app. (Berlin M. T.) h m s	δ app. °	log *r*	log Δ
Mar. 4	18 20 10	−4 22.3	0.5265	0.5553
8	24 8	3 54.9	0.5237	0.5464
12	27 58	3 26.0	0.5209	0.5372
16	31 40	2 55.5	0.5181	0.5278
20	35 13	2 23.5	0.5152	0.5181
24	38 36	1 49.9	0.5122	0.5082
28	18 41 48	−1 14.9	0.5093	0.4980

Magnitude Mar. 28, 14.2.

VARIABLE STARS.

New Variable Star 133.1910 Canum Venaticum:—This star was discovered on Oct. 14 by Mme. L. Ceraski at Moscow. Its approximate position is

	α h m s	δ ° ′
1855	12 21 57	35 28
1900	12 24 11	35 13

Eleven photographs, taken between 1896 and 1910, show that the star varies between 10^m and 11^m. The type is uncertain.

New Variable Star 134.1910 Piscium:—The variability of this star is announced in *A. N.* 4465 by E. Ernst of Heidelberg. The position given is

	α	δ
1855	0^h $27^m.3$	9° 30′

It is not yet certain whether this star is a *nova* or an ordinary variable. It was not visible on plates taken prior to 1907 but on plates taken at this time it appears as a star of magnitude 10.

New Variable Star 135.1910 Andromedae:—This variable star was discovered on December 3 by Mme. L. Ceraski. Its position is

	α h m s	δ ° ′
1855	0 6 42	28 14
1900	0 9 1	28 29

From eighteen photographs obtained between 1907 and 1910 Mr. S. Blazko has computed the elements:

Max. = 2418555 + 247 E.

The variation is between magnitudes 9.5 and 12.

New Variable Star 136.1910 Lyrae:—The variability of this star was discovered by Mr. E. Hertzsprung at Potsdam, during an investigation of the light curve of RR Lyrae. The star seems to be an Algol type variable with a period of about 5.3 days. The variation is between magnitudes 9 and 10. The position is

	α	δ
1855	19^h 22^m 49.″2	41° 24′.7

New Variable Star 2.1911 Lyncis:—On Jan. 12, Mme. L. Ceraski discovered the variability of BD +35°1821, the coördinates of which are:

	α			δ	
	h	m	s	°	′
1855	8	16	11.0	+35	52.8
1900	8	19	4 9	35	44.2

From a study of 14 plates, Mr. Blazko finds that the variable is of long period and the variation between magnitudes 9.5 and 12. The following provisory elements have been computed.

Max. = 1910 Mar. 10 + 305^d E.

New Variable Star 3.1911 Cancri:—This star is BD + 24° 1959 the position of which is

	α			δ	
	h	m	s	°	′
1855	8	28	58.3	24	3.9
1900	8	31	37.8	23	54.7

A variation between the 9 and 11 magnitudes was discovered by Mme. L. Ceraski from a study of six plates taken between 1897 and 1910. The variable is probably of the Algol type.

New Variable Star 4.1911 Cancri:—This variable star was also found by Mme. Ceraski in the same field with 3.1911. Its approximate position is:

	α			δ	
	h	m	s	°	′
1855	8	2	27	+23	35
1900	8	5	8	23	27

The variation is between magnitudes 10 and <12 and the type, uncertain.

Approximate Magnitudes of Variable Stars on Feb. 1, 1911.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn
χ Androm.	0	10.8	+46	27	13.5d	W Tauri	4	22.2	+15	49	9.6 i
T Androm.		17.2	+26	26	11.8 i	X Camelop.		32.6	+74	56	10.6 i
T Cassiop.		17.8	+55	14	9.2 i	V Orionis	5	0.8	+ 3	58	12.7d
R Androm.		18.8	+38	1	9.2d	S Camelop.		30.2	+68	45	8.2 i
Y Cephei		31.3	+79	48	13.0	U Aurigae		35.6	+31	59	10.2 i
U Cassiop.		40.8	+47	43	<13	Z Tauri		46.7	+15	46	13.8
RW Androm.		41.9	+32	8	11.5d	SU Tauri		43.2	+19	1	12.0
RR Androm.		45.9	+33	50	9.6	U Orionis		49.9	+20	10	10.2d
RV Cassiop.		47.1	+46	53	12.7 i	X Aurigae	6	4.4	+50	15	8.8d
W Cassiop.		49.0	+58	1	9.3d	V Monoc.		17.7	— 2	9	13.5d
U Androm.	1	9.8	+40	11	<13	U Lyncis		31.8	+59	57	13.8d
S Cassiop.		12.3	+72	5	13.5	S Lyncis		35.9	+58	0	9.5
RU Androm.		32.8	+38	10	10.9 i	Y Monoc.		51.3	+11	22	12.1d
Y Androm.		33.7	+38	50	9.6d	R Lyncis		53.0	+55	28	8.4 i
W Androm.	2	11.2	+43	50	10.2d	V Can. Min.	7	1.5	+ 9	2	13.0d
S Persei		15.7	+58	8	8.4	R Gemin.		1.3	+22	52	11.0d
RR Cephei		29.4	+80	42	<12.5	R Can. Min.		3.2	+10	11	7.9
X Ceti	3	14.3	— 1	26	8.9 i	RR Monoc.		12.4	+ 1	17	12.1d
R Persei		23.7	+35	20	11.1 i	V Gemin.		17.6	+13	17	8.2

Approximate Magnitudes of Variable Stars on Feb. 1, 1911—Con.

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A 1900 h	m	Decl. 1900 °	′	Magn.
S Can. Min.	7	27.3	+ 8	32	10.6 *i*	S Aquilae	20	7.0	+15	19	10.2 *i*
T Can. Min.		28.4	+11	58	<12	RS Cygni		9.8	+38	28	9.0*d*
U Can. Min.		35.9	+ 8	37	11.8 *i*	SX Cygni		11.6	+30	46	11.0*d*
S Gemin.		37.0	+23	41	13.8*d*	U Cygni		16.5	+47	35	9.0*d*
V Cancri	8	16.0	+17	36	9.3*d*	S Delphini		38.5	+16	44	9.6*d*
RT Hydrae		24.7	− 5	59	9.0	T Delphini		40.7	+16	2	11.0 *i*
U Cancri		30.0	+19	14	13.0*d*	R Vulpeculae		59.9	+23	26	8.0 *i*
S Hydrae		48.4	+ 3	27	8.3*d*	TW Cygni	21	1.8	+29	0	11.6*d*
T Cancri		51.0	+20	14	9.8*d*	R Equulei		8.4	+12	23	13.6*d*
W Cancri	9	4.0	+25	39	7.8 *i*	T Cephei		8.2	+68	5	10.7*d*
R Leonis		42.2	+11	54	10.4*d*	S Cephei		36.5	+78	10	9.0*d*
R Urs. Maj.	10	37.6	+69	18	8.4 *i*	T Pegasi	22	4.0	+12	3	10.0 *i*
T Urs. Maj.	12	31.8	+60	2	11.1*d*	Y Pegasi		6.8	+13	52	10.0 *i*
RS Urs. Maj.		34.4	+59	2	11.0*d*	X Aquarii		13.2	−21	24	11.6
S Urs. Maj.		39.6	+61	38	8.6 *i*	RV Pegasi		21.0	+29	58	8.6 *i*
U Urs. Min.	14	15.1	+67	15	11.4	S Lacertae		24.6	+39	48	8.9*d*
S Bootis		19.5	+54	16	12.0 *i*	R Lacertae		38.8	+41	51	10.1*d*
R Camelop.		25.1	+84	17	8.6 *i*	S Aquarii		51.8	−20	53	12.8 *i*
R Coronae	15	44.4	+28	28	9.0 *i*	RW Pegasi		59.2	+14	46	13.6*d*
R Draconis	16	32.4	+66	58	9.9*d*	R Pegasi	23	1.6	+10	0	10.6*d*
RY Lyrae	18	41.2	+34	34	13.8*d*	V Cassiop.		7.4	+59	8	11.2*d*
V Lyrae	19	5.2	+29	30	9.3 *i*	W Pegasi		14.8	+25	44	10.8*d*
S Lyrae		9.1	+25	50	<13.5	S Pegasi		15.5	+ 8	22	8.6 *i*
U Draconis		9.9	+67	7	11.2*d*	ST Androm.		33.8	+35	13	10.0
R Cygni		34.1	+49	58	10.6*d*	Z Cassiop.		39.7	+56	2	11.1 *i*
RT Cygni		40.8	+48	32	9.6 *i*	RR Cassiop.		50.7	+53	8	12.8*d*
TU Cygni		43.3	+48	49	9.0 *i*	R Cassiop.		53.3	+50	50	11.0
χ Cygni		46.7	+32	40	12.2*d*	Y Cassiop.		58.2	+55	7	12.2*d*
Z Cygni		58.6	+49	46	9.8*d*						

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled by Mr. Leon Campbell of the Harvard College Observatory from observations made at the Vassar, Amherst, Mt. Holyoke, Olcott, Jacobs, Hunter, Swartz and Harvard, Observatories.

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

SX Cassiop.

d	h
Apr. 28	2

SY Cassiop.

Apr. 1	18
5	19
9	21
13	23
18	1
22	6
26	4
30	6

RW Cassiop.

Apr. 7	12
22	7

SU Cassiop.

d	h
Apr. 2	3
4	1
6	0
7	23
9	22
11	20
13	19
15	18
17	17
19	16
21	14
23	13
25	12
27	11
29	9

SV Persei

d	h
Apr. 5	15
16	18
27	21

RX Aurigæ

Apr. 2	9
14	0
25	15

SX Aurigae

Apr. 2	5
3	18
5	6
6	19
8	8
9	21

SX Aurigae

d	h
Apr. 11	9
12	22
14	11
16	0
17	13
19	1
20	14
22	3
23	16
25	4
26	17
28	6
29	19

SY Aurigae

d	h
Apr. 3	22
14	2
24	5

Y Aurigae

Apr. 2	3
7	0
9	21
13	17
17	14
21	10
25	7
29	4

Maxima of Variable Stars of Short Period not of the Algol Type.-Con.

RZ Geminorum

	d	h
Apr.	2	5
	7	17
	13	5
	18	18
	24	6
	29	18

RS Orionis

Apr.	8	4
	15	17
	23	7
	30	20

T Monoc.

Apr.	14	22

W Geminorum

Apr.	5	3
	13	1
	20	23
	28	21

ζ Geminorum

Apr.	2	5
	12	8
	22	12

RU Camelop.

Apr.	7	9
	29	15

V Carinæ

Apr.	3	21
	10	14
	17	6
	23	23
	30	16

T Velorum

Apr.	1	1
	6	3
	10	18
	15	9
	20	1
	24	16
	29	7

W Carinæ

Apr.	3	7
	7	16
	12	1
	16	10
	20	19
	25	3
	29	12

S Muscæ

Apr.	6	10
	16	1
	25	17

T Crucis

Apr.	1	6
	7	23
	14	17
	21	10
	28	4

R Crucis

	d	h
Apr.	1	2
	6	22
	12	18
	18	13
	24	9
	30	5

S Crucis

Apr.	3	14
	8	6
	12	23
	17	15
	22	8
	27	1

RZ Centauri

Apr.	1	9
	2	8
	3	6
	4	5
	5	3
	6	2
	7	0
	7	23
	8	21
	9	20
	10	18
	11	17
	12	15
	13	14
	14	12
	15	11
	16	9
	17	8
	18	6
	19	5
	20	3
	21	2
	22	0
	22	23
	23	21
	24	20
	25	18
	26	17
	27	15
	28	14
	29	12
	30	11

W Virginis

Apr.	6	2
	23	9

V Centauri

Apr.	2	12
	8	0
	13	12
	18	23
	24	11
	29	23

R Triang. Austr.

	d	h
Apr.	2	14
	5	23
	9	8
	12	18
	16	3
	19	12
	22	22
	26	7
	29	16

S Triang. Austr.

Apr.	6	10
	12	18
	19	2
	25	9

S Normæ

Apr.	8	6
	18	0
	27	18

RV Scorpii

Apr.	3	4
	9	5
	15	7
	21	8
	27	10

RV Ophiuchi

Apr.	3	11
	7	4
	10	20
	14	13
	18	5
	21	22
	25	14
	29	7

X Sagittarii

Apr.	1	21
	8	21
	15	21
	22	21
	29	22

Y Ophiuchi

Apr.	10	21
	28	0

W Sagittarii

Apr.	5	7
	12	21
	20	11
	28	1

Y Sagittarii

Apr.	2	15
	8	10
	14	5
	19	23
	25	18

U Sagittarii

Apr.	3	8
	10	2
	16	20

β Lyræ

	d	h
Apr.	6	15
	12	22
	19	14
	25	20

κ Pavonis

Apr.	2	17
	11	19
	20	21
	30	0

U Aquilæ

Apr.	5	19
	12	19
	19	20
	26	20

U Vulpeculæ

Apr.	4	22
	12	22
	20	22
	28	21

SU Cygni

Apr.	2	1
	5	22
	9	18
	13	14
	17	11
	21	7
	25	3
	28	23

η Aquilæ

Apr.	6	1
	13	5
	20	10
	27	14

S Sagittæ

Apr.	8	12
	16	21
	25	6

X Vulpeculae

Apr.	5	7
	11	15
	17	23
	24	6
	30	14

V Vulpeculae

Apr.	5	7

X Cygni

Apr.	10	9
	26	18

T Vulpeculae

Apr.	1	16
	6	3
	10	13
	14	23
	19	10
	23	20
	28	7

TX Cygni

Apr.	7	0
	21	18

VY Cygni

	d	h
Apr.	2	13
	10	10
	18	6
	26	3

VZ Cygni

Apr.	1	22
	6	19
	11	16
	16	13
	21	9
	26	6

Y Lacertae

Apr.	2	16
	6	23
	11	7
	15	15
	19	23
	24	7
	28	14

δ Cephei

Apr.	1	22
	7	7
	12	16
	18	1
	23	10
	28	18

Z Lacertae

Apr.	1	6
	12	3
	23	0

RR Lacertae

Apr.	6	6
	12	16
	19	2
	25	12

V Lacertae

Apr.	1	5
	6	5
	11	4
	16	4
	21	3
	26	3

X Lacertae

Apr.	5	13
	11	0
	16	10
	21	21
	27	8

SW Cassiop.

Apr.	2	11
	7	21
	13	7
	18	18
	24	4
	29	15

RS Cassiop.

Apr.	6	10
	12	17
	19	0
	25	7

RY Cassiop.

Apr.	12	12
	24	15

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc. For stars marked with an * alternate minima are given; ** every third minimum; † every tenth minimum.]

SY Androm.

	d	h
Apr.	30	22

***U Cephei**

	d	h
Apr.	1	5
	6	5
	11	4
	16	4
	21	4
	26	3

***Z Persei**

	d	h
Apr.	3	8
	9	11
	15	14
	21	16
	27	19

RY Persei

	d	h
Mar.	2	14
	9	10
	16	7
	23	4
	30	1

****RZ Cassiop.**

	d	h
Apr.	7	14
	8	4
	11	18
	15	8
	18	22
	22	12
	26	2
	29	16

***ST Persei**

	d	h
Apr.	1	12
	6	19
	12	2
	17	9
	22	16
	27	23

***Algol**

	d	h
Apr.	3	9
	9	3
	14	20
	20	14
	26	2

****RT Persei**

	d	h
Apr.	2	20
	5	9
	7	23
	10	12
	13	0
	15	14
	18	3
	20	16
	23	5
	25	19
	28	8
	30	21

λ Tauri

	d	h
Apr.	4	1
	8	0
	11	23
	15	21
	19	20
	23	19
	27	18

***RW Tauri**

	d	h
Apr.	1	8
	6	21
	12	10
	17	22
	23	11
	29	0

***RV Persei**

	d	h
Apr.	1	19
	5	18
	9	17
	13	15
	17	14
	21	13
	25	11
	29	10

RW Persei

	d	h
Apr.	6	19
	20	0

RS Cephei

	d	h
Apr.	13	2
	25	12

***RY Aurigae**

	d	h
Apr.	4	5
	9	16
	15	3
	20	14
	26	1

***RZ Aurigæ**

	d	h
Apr.	2	5
	8	6
	14	6
	20	7
	26	8

51.1908 Gemin.

	d	h
Apr.	4	7
	8	7
	12	7
	16	7
	20	7
	24	8
	28	8

***RW Gemin.**

	d	h
Apr.	3	19
	9	13
	15	6
	21	0
	26	17

***U Columbæ**

	d	h
Apr.	1	15
	7	5
	12	19
	18	10
	24	0
	29	15

***RW Monoc.**

	d	h
Apr.	4	4
	8	0
	11	19
	15	15
	19	10
	23	6
	27	1
	30	20

RX Gemin.

	d	h
Apr.	2	22
	15	3
	27	8

****RU Monoc.**

	d	h
Apr.	2	22
	5	15
	8	7
	11	0
	13	17
	16	9
	19	2
	21	18
	24	11
	27	3
	29	20

****R Canis Maj.**

	d	h
Apr.	3	14
	6	23
	10	9
	13	19
	17	5
	20	14
	24	0
	27	10
	30	20

RY Geminorum

	d	h
Apr.	4	9
	13	16
	23	0

***Y Camelop.**

	d	h
Apr.	5	15
	12	6
	18	20
	25	11

RR Puppis

	d	h
Apr.	3	17
	10	4
	16	14
	23	0
	29	10

****V Puppis**

	d	h
Apr.	3	3
	7	11
	11	20
	16	5
	20	13
	24	22
	29	7

†X Carinæ

	d	h
Apr.	3	19
	9	5
	14	15
	20	1
	25	11
	30	21

S Cancri

	d	h
Apr.	8	3
	17	15
	27	3

S Velorum

	d	h
Apr.	6	3
	12	1
	18	0
	23	22
	29	21

****Y Leonis**

	d	h
Apr.	3	6
	8	7
	13	9
	18	10
	23	12
	28	13

****RR Velorum**

	d	h
Apr.	5	15
	11	5
	16	18
	22	8
	27	21

***SS Carinae**

	d	h
Apr.	4	6
	10	21
	17	11
	24	2
	30	16

RW Urs. Maj.

	d	h
Apr.	7	1
	14	9
	21	17
	29	1

****Z Draconis**

	d	h
Apr.	1	10
	5	12
	9	13
	13	15
	17	17

****Z Draconis**

	d	h
Apr.	21	19
	25	20
	29	22

***SS Centauri**

	d	h
Apr.	2	11
	7	10
	12	8
	17	7
	22	6
	27	5

***δ Libræ**

	d	h
Apr.	1	14
	6	6
	10	21
	15	13
	20	5
	24	21
	29	12

***U Coronæ**

	d	h
Apr.	3	1
	9	22
	16	20
	23	18
	30	15

***SW Ophiuchi**

	d	h
Apr.	5	10
	10	7
	15	5
	20	2
	25	0
	29	21

***SX Ophiuchi**

	d	h
Apr.	2	18
	6	21
	11	0
	15	3
	19	6
	23	9
	27	12

R Aræ

	d	h
Apr.	4	19
	9	5
	13	16
	18	2
	22	12
	26	22

****U Ophiuchi**

	d	h
Apr.	1	18
	4	6
	6	18
	9	7
	11	19
	14	7
	16	20

Minima of Variable Stars of the Algol Type.—Continued.

	d	h
**U Ophiuchi		
Apr.	19	8
	21	21
	24	9
	26	21
	29	10
**SZ Herculis		
Apr.	2	6
	4	17
	7	4
	9	15
	12	1
	14	12
	16	23
	19	10
	21	21
	24	8
	26	19
	29	6
Z Herculis		
Apr.	4	9
	8	9
	12	9
	16	9
	20	9
	24	8
	28	8
SX Draconis		
Apr.	1	19
	6	23
	12	3
	17	8
	22	12
	27	16
*RS Sagittarii		
Apr.	5	4
	10	0
	14	20
	19	16
	24	12
	29	8
*V Serpentis		
Apr.	3	6
	10	3
	17	1
	23	23
	30	20

	d	h
†RZ Draconis		
Apr.	4	23
	10	12
	16	0
	21	12
	27	0
** RX Herculis		
Apr.	2	11
	5	3
	7	19
	10	11
	13	3
	15	20
	18	11
	21	3
	23	19
	26	11
	29	4
*SX Sagittarii		
Apr.	3	3
	7	7
	11	11
	15	14
	19	18
	23	22
	28	1
*RR Draconis		
Apr.	3	4
	8	20
	14	12
	20	4
	25	20
**U Scuti		
Apr.	3	14
	6	11
	9	8
	12	5
	15	1
	17	22
	20	19
	23	16
	26	12
	29	9

	d	h
*RX Draconis		
Apr.	2	8
	6	3
	9	22
	13	17
	17	12
	21	7
	25	2
	28	21
*RV Lyræ		
Apr.	7	20
	15	1
	22	6
	29	10
16.1908 Vulpec.		
Apr.	1	22
	6	9
	10	21
	15	8
	19	20
	24	7
	28	18
*U Sagittae		
Apr.	1	8
	8	3
	14	21
	21	15
	28	9
Z Vulpeculæ		
Apr.	5	5
	10	3
	15	1
	19	23
	24	21
	29	19
SY Cygni		
Apr.	4	11
	10	11
	16	11
	22	11
	28	12

	d	h
*WW Cygni		
Apr.	4	4
	10	20
	17	11
	24	2
	30	17
SW Cygni		
Apr.	4	8
	8	21
	13	11
	18	1
	22	15
	27	4
VW Cygni		
Apr.	3	17
	12	3
	20	13
	29	0
*UW Cygni		
Apr.	4	2
	12	0
	17	22
	24	19
W Delphini		
Apr.	3	9
	8	4
	13	0
	17	19
	22	14
	27	10
RR Delphini		
Apr.	3	21
	8	11
	13	1
	17	16
	22	6
	26	20
RR Vulpeculae		
Apr.	3	17
	8	19
	13	20
	18	21
	23	22
	28	23

	d	h
**VV Cygni		
Apr.	4	16
	9	2
	13	13
	17	23
	22	9
	26	20
**28.1910 Cygni		
Apr.	3	13
	6	10
	9	8
	12	6
	15	4
	18	1
	20	23
	23	21
	26	19
	29	17
WZ Cygni		
Apr.	28	20
*RT Lacertae		
Apr.	3	7
	8	9
	13	11
	18	13
	23	15
	28	16
*TT Androm.		
Apr.	1	14
	7	3
	12	15
	18	4
	23	17
	29	5
21.1909 Andr.		
Apr.	4	5
	8	8
	12	11
	16	13
	20	16
	24	19
	28	22

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Does the Moon "fall" toward the Earth:—It is stated in several good astronomical books that the Moon revolving in its orbit is continually falling toward the Earth. Newcomb in his "POPULAR ASTRONOMY" states that the non-mathematical reader has difficulty in seeing that this is true and dis-

cusses the point at some length. The truth to be conveyed is that the Moon is continually deflected from the tangent to its orbit. In other words it is always nearer to the Earth than it would have been had gravitation ceased the previous instant. Some writers are apparently careful to exclude the word "fall" from their discussions of the motion.

We ordinarily speak of a body as falling when it is approaching the center of the Earth. The antonym is rising. If we can properly speak of the Moon as falling we have left no meaning for the antonym, rising. A stone thrown vertically upward could in the same sense be said to be falling, whether ascending or descending, for it is always nearer the Earth than it would have been had gravitation ceased the previous instant, and if not thrown exactly vertically it would always be deflected from the tangent even though receding from the Earth.

It appears to me undesirable and even incorrect, in the ordinary sense of the word, to use "fall" in this way.

SAMUEL G. BARTON,

Clarkson School of Technology.
Potsdam, N. Y.

Re-mounting of a 6-inch Refractor of the Lick Observatory:—On a peak not far from the main building of the Lick Observatory there is a small dome, which had formerly been located close to the main building, with a six-inch telescope mounted in it. But when the dome was moved to the present location the telescope was dismounted. Recently, through the courtesies of Director Campbell, Dr. Aitken, Dr. Curtis and others I have been given the privilege of using the dome and the telescope when no one of the observatory staff used it. To get it into working order the dome required repairing, with a new floor and steps, and the telescope needed remounting, with some adjustments. But the observatory kindly took all these extra troubles and fixed it very fine. The telescope is a six-inch objective provided with a clock work, circles, micrometer, etc. I intend to use it for various astronomical purposes as useful as possible within the limit of my power. I take this opportunity to give my hearty thanks to the gentlemen of the Lick observatory concerned upon this subject.

M. Yamasaki.

Feb. 15, 1911.

An Amateur's Observations of Halley's Comet.—The following observations were made with an excellent Zeiss telescope of 1⅜-inch aperture and 29 inches focal length, and are about all that could be expected from an instrument of that size although it is probable that the comet could have been discovered several weeks earlier. The dimensions of the comet were estimated by the known diameter of the field (100′), and the magnitude, by comparison with stars in the field. The position angles were estimated with the help of a planisphere.

Jan. 30. 8^h Discovered in finder after ten minutes search. Very small, hardly any visible condensation, no trace of a tail, about $9^m.2$. Diameter 4′±
Color, whitish yellow.

Jan. 31. 8^h Comet slightly larger. No condensation. Diameter 4′ 30″±
Nearly globular, as yesterday. 9th magnitude.

Feb. 1. 8^h About the same. Perhaps slightly elongated in position angle 73°±, which is about where a tail would appear. Proportion, length to breadth, 5:4. Diurnal motion greater than yesterday.

Feb. 3. 9^h 15^m Marked central condensation. Total magnitude $8^m.7$ ±. Diameter, a little over 4′. Diameter of condensation 2′ 30″ ±. Edges of condensation ill-defined, but center bright, almost amounting to a nucleus. Still slightly elongated in P = 70° ±.

Feb. 4. 7^h 30^m Much brighter, central condensation. Diam. 4′ 30″ ($8^m.2$) Almost exactly round.

Feb. 5. 7^h 50^m Comet fainter, smaller. ($8^m.5$) Traversely elongated in position angle 160° ± L:B = 4′:3′ Condensation still visible.

Feb. 6. 7^h 20^m About 8th magnitude, slight condensation, perhaps triangular. Diameter = 4′±,

Feb. 12. 8^h Comet very much larger and probably brighter, but near Moon. Slightly brighter in center, but no condensation visible. Diameter 8′ 20″ ±. Magnitude about 7.8.

Feb. 13. 8^h Marked condensation, well defined, round, and nearly uniformly bright, much like the drawing in POPULAR ASTRONOMY, Vol. XVIII, page 360, dated January 25th, 1836, or in Herschel's "Outlines of Astronomy" of the date of January 24. Diameter of condensation = 5′ ±. Diameter of comet 12′. Coma ill-defined and faint. An $8^m.5$ star at s. f. edge of coma.

April 20. 5 A. M. Comet found with opera glass. It presented a fine appearance in the telescope with powers 30 and 60, the head was $2^m.5$, diameter of coma 8′ ±. Star-like nucleus, with dark space behind, darkest directly behind nucleus, then fading rapidly away. The sides of the tail, which could be traced to 10° — 15°, were brighter near the head, almost amounting to two jets, continuing for about 15′, then ending rather abruptly, their edges curving into the edges of the tail.

May 12. 4^h 20^m. Magnificent this morning. Star-like nucleus, small coma, tail very bright, single, straight, 30° — 40° long. Tail relatively brighter near head for about six degrees, then fading more evenly away.

Nothing remarkable was seen on May 18th or 16th.

May 23. 8^h 15^m Very fine, but air misty. Tail traced to 40°. Fan shaped jet seen issuing from nucleus, which was irregular toward s. side of field, in position angle 210°, reaching almost to edge of coma, edges bright, middle dark, like the tail of April 20th. Five stars (8m—9m) visible in coma. Diameter of coma = 19′±; of nucleus, 5″. Magnitude of head 3m ±. Magnitude of nucleus about 4th. Position angle of tail (*in field*) 80° ±.

May 24. 9h Coma and upper part of tail well defined Nucleus small, diameter of coma about 20′. The star AG. LPZ. II 4615 was then (9h) 11′ ± from the nucleus, which had passed over it some time before (see A. N. 4417).

May 25. 9h 20m At its best tonight. Tail over 80° long, comet altogether about $2^m.5$. Nucleus much larger, round. An eighth magnitude star only 3′ from nucleus, which apparently passed over, or very near it before. Tail near coma broader. Diameter of coma = 20′ Position angle of tail (in field) 90°.

May 26. 8h 30m Still very fine. Tail now much narrower near coma, not as broad as the coma itself. Nucleus smaller, coma round, well defined, quite unlike comet *a*, 1910. Seven 8m—9m stars in coma and tail. Dimensions about the same.

May 27. 9h 20m Still almost as bright. Nucleus passed within 20′ south of Σ 1343. Nucleus transversely elongated, in P = 360° ±. L:B = 13:2.

Apparently pointed on both ends, well defined on off-sun side. Coma less well defined, tail as broad as coma again. Coma extended 13′ in front of nucleus.

May 28. 9h 30m Slightly fainter. Coma fairly well defined; its diameter was 18′ ±. Magnitude of head about 3.

May 29. Perceptibly fainter, although still with nucleus and bright globular coma. Tail remarkably broad near head. Nucleus elongated in P = 93° ±. L:B = 3:2.

May 30. 9h 45m A good deal fainter (whole comet about 2m, head, 4m). Diameter coma = 16′. Diameter of tail one degree from coma = 19′. Nucleus near head of coma, slightly elongated in P = 135° ±. L:B = 4:3; edge straight toward Sun, curved on other side,

May 31. 9h Still easily visible to the naked eye. but it has lost its glory. Nucleus small. Magnitude of whole comet = 3 ±. Tail about 25° long, and faint. BD + 2.2264 passed within 10′ of the nucleus.

EDWARD H. WISSER.

Savannah, Ga. Dec. 3, 1910.

The Equatorial Belt on Saturn.—In taking an observation of Saturn on the night of Dec. 3, I noticed that the equatorial belt was quite bright and distinct. Would like to hear from other observers, through your most interesting paper, whether they noticed the same also.

GUS A. DUERLER. JR.

San Antonio, Tex. Dec. 6, 1910.

Observations of the Planets in Porto Rico:—At the October elongation of Mercury, we observed it with considerable care. Clouds prevented our catching it as soon as we think we otherwise might have done. We saw it, however, first on October 2, very plainly, and about an hour from the Sun. We saw it with the naked eye on the morning of October 31, or twenty days after greatest elongation. It was then less than nine degrees from the Sun. Venus was also seen a degree and a half or so nearer to the Sun. I followed it with the glass until about Sun up and could pass from one planet to the other and back again. On the morning of October 2, I could not see either with the naked eye but located Venus with the glass by the distance from the Sun after sunrise, about six and one half degrees from the latter, but I could not then see Mercury though I supposed it would be very close, perhaps both within the field of the telescope. I was in a hurry and perhaps did not take time to locate it.

Jupiter has been clearly visible since November 1, and on that date I saw it with the naked eye. I mention this, as well as the observation of Mercury, to call attention to the great advantage of position, and especially of atmospheric conditions, which we enjoy in Porto Rico. After eight o'clock in the evening and until morning the sky is intensely clear, and we can often see comparatively faint stars within twenty one degrees of the south pole. Many of the most interesting telescopic objects are between forty and seventy degrees south latitude. Porto Rico is an easy trip from New York or Boston. Is it not worth some "able man's" while to establish an observatory on this health resort of Uncle Sam, so recently exploited? The nascent university at Lajas P. R. struggling for life, was recently left at our door, by a careless, or perhaps overburdened government, and now under the able guidance of Rev. J.

Will Harris, of San German, is getting upon its feet again. We should be delighted if some university or liberal individual would look down this way with one of their big telescopes. Why go to the Philippines with Porto Rico so near and equally good?

E. A. McDONALD.

Isabela, P. R. Nov. 9, 1910.

GENERAL NOTES.

Owing to an extraordinary sale, No's 156, June-July 1908; 161, January 1909; 169, November 1909; 170, December 1909, are out of our files. Requests for these numbers have not been numerous enough to warrant the reprinting of any of the issues, but still a number of our subscribers need them to complete their files of POPULAR ASTRONOMY. If any of our readers, therefore, have made all the use they care to of these numbers, and care to dispose of them, we should be very glad to buy them back at the rate of 30 cents a copy.

Mass-ratios of Krueger 60 and Castor:—In the *Astrophysical Journal* for December Professor H. N. Russell of Princeton gives a determination of the mass-ratio of the components of the double star Krueger 60 ($\alpha = 22^h24.5$ $\delta = +57°$ 13′, 1900), in which he finds the mass of the fainter component (magnitude 11.0) to be slightly greater than that of the brighter component (magnitude 9.7). The ratio comes out 1.14 ± 0.14. The parallax of the brighter star is 0″.25 and the proper motion of the system with reference to a distant tenth magnitude companion is 0.″866 in position angle 244°.9.

Professor Russell also discusses the mass-ratios of the spectroscopic components of Castor. Both components of this familiar bright double star are spectroscopic binaries. By means of the data furnished by the spectroscopic observations of H. D. Curtis at Lick Observatory, Russell finds the "apparent masses" of the two invisible stars to be exceedingly small compared with that of the Sun. By "apparent mass" he designates the expression $\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$, where m is the mass of the bright star, m_1 that of the invisible attendant, and i the inclination of the orbit. If $\frac{m}{m_1} = c$, the actual mass of the system is $(1 + c)^3 \csc^3 i$ times the apparent mass. The following are the results obtained for the two pairs:

	$a \sin i$	Period	Apparent mass.
α_2 Geminorum	1,485,000 km	9.^{d}219	0.0015 ⊙
α_1 Geminorum	1,279,000	2. 928	0.0097 ⊙

"The apparent mass of the fainter component is six times that of the brighter; but the sum of the apparent masses of the two is only $\frac{1}{600}$ of the real sum of their masses, previously determined. It is evident that, for one or both of the close pairs, c must be large or i small. Beyond this they are at present unknown and hence the ratio of the apparent masses tells us nothing about the real mass-ratio.

"If the planes of the secondary orbits are approximately coincident with that of the visual orbit (which seems plausible) and c is the same for the two close pairs, it must be about 6.5. If less than this for one pair, it must be more for the other. This is a much greater preponderance of the primary than has appeared in any of the systems susceptible of reasonably exact investigation. The greatest well-established value of c is 3.0 in the case of Procyon. To get as small a value in the present case it would be necessary to assume that the orbits of the close pairs are inclined less than 30° to the plane of projection—that is that both are inclined at least 35° to the visual orbit, and that the ascending nodes of both on this plane lie near its descending node on the plane of projection. This seems rather improbable, and the difficulty increases if we assume smaller values of c. It is therefore probable that the 'dark companions in these two spectroscopic binaries are less massive in comparison with their primaries, than is the case in any systems previously investigated."

The Next Great Astronomical Discovery.—The address given by the retiring president, H. P. Hollis, at the October meeting of the British Astronomical Association, furnishes a very readable account of the progress which has been made in astronomy in the past thirty or forty years. The address is of such a nature that one can not make a brief summary of it; it is a summary in itself and must be read as a whole.

Toward the close of his remarks he asks the question, quoting from another speaker: "Which is the greatest discovery in astronomy?" The answer given by the other speaker was, "The one that is going to be made next." Mr. Hollis says, "The answer, I think, is only partially true, or rather, like other attempts at epigram, it assumes too much; but it is a good thing to keep in mind that we are not yet at the end, and that there are more discoveries to be made, more inventions to be invented. It is sometimes useful to make guesses or estimates as to the next invention, and I suggest to you now that the next discovery may have some relation to magnetism. Fifty years ago August Compte said we should never know anything of the material of the stars, and ten years later the spectroscope was applied in the way we are now familiar with. Is it too much to expect that an instrument will be invented by which we shall be able to observe or register the magnetic or electrical qualities of the stars? No one may be able to devise an instrument like this at the moment—I think it necessary to say that I am not suggesting that wireless communication with Mars is one of the immediate possibilities—but magnetism and astronomy seem to be combining in unexpected ways and the idea I put to you does not seem unreasonable." Mr. Hollis then speaks of Zeeman effect or change in the appearance of a spectrum which results from passing the light through a magnetic field, and its application by Hale to the study of sunspots; and of the investigations by Professor Ernest Brown of the possible effect of magnetic attraction between the Earth and the Moon, citing these as instances of the intimate connection between physics and astronomy. He cited also the wonderful computation of the orbit of Comet Halley, which gave the predicted time of the comet's perihelion within three days of the actual time shown by the observations. Dr. Cowell and Dr. Crommelin have assured themselves that there is no error in computation, and that the

attractions of all matter that is known to exist have been taken into account; therefore since there is this difference of three days, there must be some forces now unknown at work. It will be curious if the computation of a comet's orbit should lead to the discovery of a new physical law."

The Isaac Newton Studentships in Astronomy.—The late Mr. Frank McClean, besides being an active and keen astronomer, who produced with his own hands some of the best of the spectroscopic records that exist, helped the science in other ways by means of his ample fortune. He gave a large telescope to the Cape Observatory, and he gave a large sum of money to Cambridge University to endow certain studentships to be held by men after taking their degree, who were to devote themselves to the study of astronomical optics. I think the second of his two gifts was the more effective. It has been said that to offer a prize for some particular research in astronomy or any other science which leads to competition, is not a good thing, because the work of the unsuccessful competitors is not brought to light, and there is a waste of energy; but these prizes are of rather a different kind. We see examples of cases in America at the Mount Wilson, Harvard and Dudley Observatories, where men who have proved themselves to be geniuses of research have means placed at their command in the way of instruments and observatories, by which they can give their genius full play. This is perhaps rather a better plan than giving the telescope first and finding the man afterwards, but it seems to me that a better plan still is to create the man, and at the present juncture astronomy will be best served by the importation of keen brains and minds devoted to solving some of the astrophysical problems now before us. (H. P. Hollis in his address as retiring President of the British Astronomical Association, Journal B. A. A. October 1910.)

Origin of the Lunar Surface Formations.—Mr. Walter Goodacre F. R. A. S. in the October number of the Journal of the British Astronomical Association reviews Dr. See's article on the above subject, which appeared in the February number of the Publications of the Astronomical Society of the Pacific criticizing unfavorably the main points. His concluding paragraph is:

"The effect of reading Dr. See's article, so far as I am concerned, has been not to shake my faith in the volcanic theory, but rather to confirm it as being the most probable cause of the origin of lunar surface formations."

The Average Uniformity of Certain Markings on the Planet Jupiter.—In the November number of the Journal of the British Astronomical Association Mr. Scriven Bolton describes his observations of certain wisplike markings on the white equatorial belt of Jupiter during the last eight years. He finds that dark spots are situated on the average about 15° apart along the north and south edges of the equatorial zone and that wisplike markings extend diagonally from the north spots to the south ones, the wisps from alternate spots extending in different directions, so that they intersect one another at the equator, forming something like a trellis-work structure. Sometimes one of two series of wisps is visible without the other. When both are visible the wisps are of a fainter character.

The Spectrum of Halley's Comet.—In the Proceedings of the Royal Society No. 573 Mr. Charles P. Butler gives an account of observations of the spectrum of Halley's comet at the future site of the Solar Physics Observatory at Fosterdown Fort, Caterham, in England. In the visual spectrum on May 22, 23 and 26 the nucleus showed a very strong continuous spectrum, intensified by three bands in the yellow-green, green and greenish-blue regions, presumably the usual cometary bands at λλ 5635 (intensity 7), 5165 (int. 10) and 4737 (int 7). The spectrum of the coma surrounding the nucleus was seen to consist of these same three bands, extending the whole length of the slit. Careful examination failed to detect any continuous radiation in the coma spectrum. The spectrum of the tail could not be observed under the working conditions. The photographic spectrum shows two very conspicuous bright bands, about wavelengths 4737 (intensity 10) and 3884 (int. 7), with several other fainter bands at λλ 4060, 4360, 5165, and 5635. An interesting difference noted between photographs taken in India May 1, 3, 13, and in England May 26 is the relative inversion of intensity of the lines near λλ 4737 and 3883. From a series of preliminary experiments it has been found that very remarkable changes of these carbon bands may be brought about by simple variations of the conditions of volatilization.

Did the Tail of Halley's Comet Affect the Earth's Atmosphere?—This is the title of a paper of some length by Dr. John Aitken, F.R.S., in Pt. VII, Vol. XXX of the Proceedings of the Royal Society of Edinburgh. Dr. Aitken attempted to determine whether there was any increase in the amount of dust in the atmosphere following the passage of the Earth through the tail of the comet. Selecting a location in Scotland quite free from local sources of dust pollution, near to where he had made similar observations fifteen years before, he made a series of comets of the number of dust particles per cubic centimeter of air, extending from May 14 to May 30. He found no abnormal amount of dust until the 24th and 25th, when there was an amount for which he finds no satisfactory explanation. During June and July he made systematic observations of the haziness of the air and found that it there was much more haze than fifteen years ago. Dr. Aitken, however, is very hesitant to ascribe these effects to substance which has come to us from the comet. He says: "there is no evidence to show whether or not the change in the upper air was due to the comet, then it would seem no be indicated that our atmosphere is rapidly getting more impure from local pollution, the fact, however, that the increase in dust and haze was almost entirely observed in anticyclonic areas seems to negative this supposition, as local pollution is most likely to affect cyclonic areas. Whatever the cause of the increase may be, one thing is very evident, and that is our great ignorance of everything connected with dust and haze; and it does seem desirable that they should be subjected to more systematic observation in the future than they have been in the past. Dust, like water vapor, is an everpresent constituent of our atmosphere; like it, is present in ever-varying quantity; and, along with it, plays an important part in meteorological phenomena."

Gustave Leveau, astronomer at the observatory of Paris, died on Jan. 10, 1911 at the age of 70. He had been connected with the observatory since 1857, starting as a computer under V. Puiseux. Later he came under the supervision of LeVerrier and with him finished his education in the finer

details of mathematical astronomy. In 1884 he was appointed astronomer and has since held that position.

His work may be divided into two classes, meridian circle work and celestial mechanics. From 1868 to 1888 Leveau worked with the meridian circle and during those twenty years obtained 20000 observations principally of stars in the catalogue of Lalande. But it is for his work in celestial mechanics that his name will be remembered. After some work concerning the planet (103) Hera, published in 1878, he took up a very accurate study of the perturbations of d'Arrest's comet and later carried out what might be called his most important work, an application of the method of Hansen to the theory of the tables of Vesta. As a reward for this work he was awarded in 1892 the Damoiseau prize of the Academy of Sciences.

The Night Skies of a Year:—To one who is interested in studying the constellations and in watching their seeming changes in shape with the different seasons, this book will be a source of a great deal of information and pleasure. It is written in journal form, a sort of a novel idea in its application to astronomy. The author takes up the study month by month, assuming a sufficient number of observing days in each month to give a very detailed account of the positions and forms of the constellations during the month. The book is profusely illustrated with diagrams of nearly all the constellations in their different apparent shapes. It contains a summary of the more important celestial objects visible each month and an index to all the subjects treated. For one just beginning the study of the constellations this would make an excellent text. The book is written by Joseph H. Elgie, a Fellow of the Royal Astronomical Society and is published by Chorley and Pickersgill Ltd., Leeds and London.

College Mathematics Note Book. There has recently come to our desk from Ginn and Company a note book arranged for use in College Mathematics. The book has been planned by Dr. Robert E. Moritz, Professor of Mathematics in the University of Washington. The first three pages are filled with formulas taken from Algebra, Trigonometry, Analytical Geometry, and Series. A total of one hundred and six of the formulas most frequently used are given. These add much to the value of the book for it is not very likely that the student in going over the work for the first time will remember all the formulas and he will find it very convenient to have them right at hand in the concise and compact form that is used in this book. The book is supplied with ninety-five sheets of paper ruled on one side for ordinary writing, and on the other in cross section. In addition to this another valuable feature is found in the five sheets of paper ruled for plotting in polar coördinates. It would assist the student in grasping the idea of polar coördinates to study the ruling of these sheets. The book is concluded with a series of seven tables including logarithms, natural functions, squares and square roots, cubic and cube roots, reciprocals and hyperbolic functions. On the last page are given a great many of the well known curves drawn on cross section paper, which could be very useful for reference. These sheets are bound by a loose leaf device in a substantial board cover and the book may be enlarged at any time by the mere addition of more paper. The book is evidently well adopted to its purpose, and will doubtless come into wide use.